MYCOLOGIA

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CHARLES THOM

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MYCOLOGIA

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XLVI JANUARY–FEBRUARY, 1954 No. 1

THE COLONY [1]

CHARLES THOM

Colony is an old dictionary word which includes in some sort of entity a lot of individuals presumably of one species. It might mean a hive of bees or a settlement of humans. The bacteriologists adopted it because in their cultures great numbers of bacteria appear massed into more or less characteristic aggregates. The mycologists came into the culture field a bit later, and just took the word over, because the mycelium developed from one or more spores, at least in its beginning, acquires considerable resemblance to a bacterial colony. The mold colony then, as an expression of the characteristic habit of growth of the species, appears in the literature about the time that the use of petri dishes and solid or semi-solid materials became parts of standard laboratory procedure. The loosely covered petri dish and the slanted test tube plugged with cotton have been synonymous with aerobic culture for both molds and bacteria ever since their introduction, three quarters of a century ago.

Now suppose we begin by looking at what we generally regard as the typical bacterial colony. It may have developed from one cell or many without noticeable difference in its general appearance as it develops on the surface of the nutrient substratum. At first every cell lies in contact with the food supply. Since the rate of bacterial multiplication is fabulous, the central area is quickly covered; new cells are forced outward at the margins, then upward, as soon as the original spot is already covered. As the original few cells become multitudes, the mass may become 5 cells deep or 500. In liquid culture, they might scatter and each have direct contact with food. But look at our colony. At the bottom of

[1] Presidential address, Mycological Society of America. Presented September 7, 1953, at the Society meetings in Madison, Wisconsin.

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the mass each cell reaches the food supply directly: what about the successive layers upward in the pile? The characteristic shape of the pile does not interest us at the moment. There is abundant literature on that.

We have called the pile aerobic. The cells on top of this pile are in direct contact with the air; they are also fully exposed to the effects of changes in light, temperature and humidity: What about those in the interior of the pile? The growing cells are pliable—they readily fit together. Did you ever see a pile of pigs on a barn floor on a cold night smother individuals to death in the bottom of the pile? I have. Every active bacterial cell is a wet cell—as long as multiplication proceeds every cell involved is wet. They pack tightly; all open spaces between cells are filled with fluid. Colonies vary characteristically in depth with the species—the depth may be the thickness of a few cells or a great many —there is every grade of pressure and exposure or smothering-power between. Bacteria may not be pigs but how much difference is there except size?

Look again at the single organism—it may be any shape from a coccus to some variety of rod. We recognize it under the meiroscope as a fairly definitely shaped protoplasmic body with a definite wall about it. That wall may be very thin. Flagella may protrude or not. In active cultures it is always wet with something. Cells may divide so rapidly that the wall always appears thin or the rate may slow down and permit successively developed layers of new wall to be laid down inside the primary wall until the mass visible under the microscope is called a capsule. Imagine for yourselves a cross section of a box of oranges! Or cucumbers! Or melons! Quite frequently the outer wall is broken down into semi-liquid or slimy or sticky products which bind thousands of cells together, making characteristic masses whose textural contrasts are part of species characterization.

Cytologically, there is nothing unique in this story. We have fungus spores which follow some of the same lines of development. The newly formed protoplasmic unit surrounds itself first with a very thin wall, then with successive layers of new wall, each inside the previous wall; thus the cell protects itself. Some of them break down the outer layers to waxy, gummy, sticky or slimy forms, each fitting some special means of dispersal. They vary from cells with a firm dry outer wall to thin walled units imbedded in slime. The red algae produce conspicuous masses of such thickened walls. For example, shreds of agar-agar will imbibe water and swell to show several successive layers about the cell lumen which shows the dried remains of the protoplasmic unit.

Now put these bacterial cells as described into a mass—the colony, and what have we? Wet with water only the colony spreads and produces a thin, sloppy layer of cells. You can find every variation from species which spread as thin watery growths over the surface of the agar to stiff waxy masses which take odd forms. The shape which a colony assumes is therefore directly dependent upon the way the species acts in the production of masses of cells—modified by the environmental conditions of the particular laboratory, especially temperature and humidity; I know a laboratory where the prevailing relative humidity is about 20%, and another where it is 70–85°—where agar does not dry up in months.

In addition to the variable results due to humidity, there are in some species strains, some of which present a smooth upper surface and, in the same species, strains whose upper surfaces are rough or irregular. Similar contrasts are not uncommon among mold colonies. In the smooth (velvety) mold colony, cell multiplication is practically restricted to the margin; in the rough surface one of several types of cell multiplication appears in the central area; submerged branching covering buckling. Aerial branches appear as tufts or fascicles. There are many differences in detail but all based upon continued cell multiplication. The cytology involved is not even guessed at here. It is not difficult to account for the rough bacterial colony by similarly continued cell multiplication. Very slight variation in the texture of the slime, will cause the changes in the masses of cells so that they pile up in one case and flatten out in the next. Some colonies under the microscope are apparently quiet; others may be a seething, boiling mass.

I have thrown at you the statement that the colony, instead of being an ideally aerobic growth, may be anaerobic, at least in the center. Am I crazy? Wait a little. A colleague of mine years ago (Dr. Shippen) was assigned a part in our study of botulism. *Clostridium botulinum* is definitely anaerobic. Shippen had in his personal collection a yeast with which he was thoroughly acquainted. He simply mixed detoxified spores of his botulism organism with his yeast, planted the mixture in petri dishes, incubated it, then killed his yeast by temperature which would not interfere with the toxin of botulism. He fed the material to the experimental animals. They died of botulism. Clearly then, the yeast growing in the petri dishes furnished conditions making it possible for the anaerobe to grow and produce toxin.

Years afterward, working in a yeast factory, two of us found yeast cells produced as for bread making with tufts of long rod bacilli attached to their cell-walls. We did not finish the job, but another man tells me they are not uncommon on most brands of commercial yeast in America and

in Europe. He adds that they readily quit their sheltered spots for independent growth when conditions suit them. And yeast is supposed to be a pure culture! Manifestly the bacilli have sought the attachment to yeast cells as at least a partially anaerobic situation.

In another series of cultures in our laboratory, a series of molds were inoculated with the same botulism organism and the incubated cultures were fed. Here again botulism was produced. We considered these molds to be in aerobic culture but anaerobic bacteria were clearly able to grow in intimate association with their hyphae.

To summarize these comments about bacteria, organisms buried in the center of such colonies as I have described are more or less completely deprived of oxygen and even more completely severed from the food supply. Actively metabolic units are packed together, with such interspaces as remain filled with slimy material and loaded with the waste products of metabolism. The bacterial colony thus offers an environment varying from abundant food and oxygen to progressive depletion of both. The upper layers of any such mass of cells are more or less completely dependent upon the ability of nutrients to percolate through the mass so described.

Now let us look at the mold colony as grown in the petri dish. It also may start out from one spore or many. Routine practices quite generally insure the use of large numbers of spores at each point of inoculation. For the study of colonies, all spores introduced for that colony are usually rather closely aggregated. If you look at them for germination, a few spores begin to grow in several hours; others seem to be germinating at the end of the first day. Many of the remainder do not develop, probably because inhibited by the activity of the early ones. Much of the inoculating material is lost.

Suppose we follow the details of colony development. Germ tubes from the spores elongate, divide, branch and rebranch indefinitely. You all know the story. In search of food the branches turn outward in a general way radially from the center—the oldest cells in the center stay there, and usually stop dividing—the newest cells are cut from the tips of hyphae pushing out into fresh food supplies. New cells lengthen at first, pushing the growing point ahead of them into fresh media—untouched food—but they soon stop lengthening. They commonly branch to fill all the space between main hyphae. The branching system radiating out from the center becomes a crowded mat often showing several layers of hyphae, whose cells have passed from the lengthening or rapidly growing stage toward its spore producing phase. It was among such hyphae as these that our botulism organism grew and produced its toxin.

In such a dense mat, cells in the upper layer might starve for food while those in the lower layer approached anaerobiosis. You and I have seen hundreds of colonies that looked to be dead in the central areas.

In the Pre-Clarkian era we had no pH apparatus so we put litmus in our culture media. It may have been crude but when we started with Czapek at or close to neutrality we had a quick way of knowing if the reaction changed. Finally, we got a micro-pH apparatus and a man trained to use it. Taking a petri dish culture of *Penicillium chrysogenum* in Czapek agar for one illustration, a test in the unchanged agar at the edge of the dish would show the original pH 6.8; in the agar just beyond the edge of the colony, acid fermentation would already show; under the marginal zone it might be pH 5.5; back toward the center of the colony, it would finally reach pH 7.5 or even 8.0. The color of the colony commonly follows the fermentation change—at the growing margin it is usually white or some tint of yellow. As a zone of spore formation appears the zone assumes one of the brighter tints of green, blue green or yellow green, i.e. in the zone of pH lower than the original pH 6.8. In the older areas where the pH is again from pH 7 to pH 7.5 or even 8, darker shades develop, often losing all green to become brown in center. In *Aspergillus flavus* this change is reversible all the way from green to brown shades and often back again if acid is used. Every imaginable variant, strain by strain, may then be found within the variation range of the species. Many of the contrasts produced are striking. Is it any wonder that some of the spores are viable and some very slow to germinate or even dead?

In other words I am picturing for you a cycle of visible changes which parallel the biochemical story. When Penicillin production came to America, we started with "still" cultures— essentially the story of the petri dish, modified only when the colony was grown upon the surface of a still liquid. We got as a yield a few Oxford units to the milliliter.

The producers then switched to tanks. The yeast men had long used them. Herrick had already worked with one mold in tanks and the Herrick-May group had made a start using *Penicillium chryogenum*. But it was still mainly "cut and try." Jump by jump they pushed the yield up until 3000 units are now a goal occasionally reached—sufficiently hopefully that some of the more optimistic ones are casting longing eyes at even higher figures.

But this is only incidentally a Penicillin story—now let us go back and see how our story connects up with the colony we knew so well (or thought we did) in the petri dish. We had found out that mycelial cells in our petri dish colony first showed spore production about four days

after they were formed in the cell multiplication zone at the growing margin of the colony; meanwhile the margin had gone on beyond by about four days growth. The conidiophores began to form first, then the green spores appeared beginning in about that period. The Penicillin workers correlated the beginning of Penicillin formation with the appearance of the zone of green. In other words, the stage of cell development at which spore formation appears is about the stage at which Penicillin also begins to appear.

In the colony, stages all the way from cell multiplication to massive spore production are present at once. The whole center of the colony is often covered with spore masses and often tests at pH 7.5 or 8. Breakdown of cells and penicillin occurs when the figure goes farther than pH 8. In contrast, if a tank is heavily inoculated, actively stirred with air enough blown in and well enough distributed to speed up cell multiplication, a maximum concentration of cells all in active condition is produced quickly. Disregarding details of procedure, the whole multitude of cells tends to pass through the reaction stages and reach Penicillin production at nearly the same time. The completeness with which this ideal is attained determines how closely the yield approaches a maximum. From the standpoint of Penicillin production the colony is not a success.

I brought the tank story in for the purpose of emphasizing that the colony as we have studied it for years is not and can not be made the maximum producer of a selected biochemical product. For colony value, we must look elsewhere. I suppose I have spent as many years as any of you in exploring the possibility of using the petri dish colony as a means of establishing mold nomenclature. Nature rarely gives us a colony that we can reproduce in the laboratory. In fact, a separate characterizable mold colony is rarely found and even if found once might not be seen again because the conditions which produce it would not occur again. Hence, it would be worthless. When I began nearly 50 years ago, the finder of a mold usually induced it to grow by any means convenient, described his procedure more or less (mostly less) completely, referred his description to the place where he found the thing rather than to the conditions under which the colony grew in the laboratory. Each organism was a separate problem and its microscopic morphology, form, measurements, color and all were supposed to be fixed. Saccardo shows hundreds of brief descriptions referred back under habitat to an indefinite place which the describer cited. Little or no comparative work was done.

The next phase of mold description recognized variability, made up a lot of media and gave a 3 to 5 line comment on each. No two workers made

up the same series of nutrients and few of them described their media accurately enough for repetition. There was still little comparative work. I have been many times driven to look at a man's figures to find out how he used his morphological terms. Some of the species described may be identified. For the most of them, the describers failed to tie concrete colony morphology to definite conditions of culture.

Czapek, meanwhile, for his biochemical research, proposed a comparatively simple formula which served his purpose. My colleague, Dr. Dox took over Czapek's formula and modified it slightly as a basis for enzyme studies with certain Penicillia and Aspergilli. He was a chemist, not a morphologist, but he suggested that I try it. This led toward a rigorous standardization of nutrient medium and culture conditions. Especial emphasis was placed upon the inclusion of only such components as can be obtained in any land where biological laboratories are maintained. With the mold groups that I have handled with frequent repetitions of culture, the colonies produced have been sufficiently dependable to warrant use of the data obtained in classification. Supplementary studies on modified formulas are always advisable and often necessary.

The possibility of cultural exploration in establishing metabolic limits of variation for a particular organism have never been reached. The biochemists have defined many of them by producing culture media containing calculated essentials of chemical elements, carbohydrates and amino acids. Unfortunately much of this information is specific to the strain used and establishes no fundamental principle. I listened while one man discussed his pet organism, then asked him if and how he had gone back to nature to find other related or identical strains for comparison. He answered, "I have a culture—I am not interested." That may have been 10 years ago—he is still working with it. I walked into Professor Peltier's office at Lincoln, Nebraska, one day 15 years ago. Sight of me provoked an impromptu lecture upon bacterial ecology. He upbraided us all and singly for getting a culture from somewhere or nowhere and spending all our time upon it, *in vitro*, without ever going out and exploring to find if it had a significant place in nature. Whatever criticism may be offered against his thesis the fact remains that we have a lot of organisms described which have been picked up somewhere but whose real significance in nature, if any, is yet to be found. Have we been chasing a colony which will present any organism in pure culture and forgotton too often why the organism should exist at all?

The colony developing upon the surface of a nutrient substratum is quite generally accepted as the characteristic response of the particular microorganism to that special aerobic environment. The growth con-

ditions presented are usually more or less arbitrarily selected for the investigator's purpose.

Certain limitations must be considered:

1. The environment presented is rarely optimum for the species selected.
2. Extremes of variation must be defined upon special nutrient media.
3. Culture is satisfactory if repetition produces reasonable uniformity of colony characters.
4. The colony may not, even usually does not, resemble the growth originally seen in nature.
5. Uniformity of growth throughout the colony is not common.

Thus far there is no dissent. How aerobic is the colony? We know that *Clostridium botulinum*, the anaerobic botulism organism, was planted in connection with several different species and produced toxin enough to kill the test animals. We have seen tufts of microaerophilic long rod bacilli attached to the walls of bread yeasts, a refuge which they appear to abandon when favorable conditions recur.

In spite of some evidences of unity in the field of spore production, consideration of many observations from recent work indicates that in the field of metabolism the cells in the mold colony still retain a large element of independence. In other words, they depend not upon each other for nutrients but rather completely upon the food materials immediately around them. Thus, they resemble the bacteria. A bacterial cell at the bottom of the pile may be in direct contact with abundant nutrient but it may be quite completely shut off from oxygen. In contrast, the several layers of cells between that and the uppermost are progressively shut off from food stuffs. The balancing of their supplies and privations determines the thickness of the colony according to species. The same principle applies in the mold colony. The central area becomes quickly static. Where several colonies lie near each other zones of inhibition commonly appear. Apply the same test to the colony itself and the older areas are seen to become rather quickiy static and often essentially dead.

In tank culture, colony structure is broken up as completely as possible, optimum nutrients are supplied, optimum contact with oxygen is provided. Such adjustments raised the yield of Penicillin from a few Oxford units in the colony in the hands of Fleming and Flory to the 2000 to 3000 obtained in the best operated tanks today.

Nevertheless, the colony growing under standardized conditions remains our best means of describing and identifying the saprophytic molds.

PORT JEFFERSON,
NEW YORK

NOMENCLATURE OF THE FAVIFORM TRICHOPHYTONS

G. C. Ainsworth and Lucille K. Georg

As the result of investigations on the nutritional requirements of the faviform trichophytons, Mackinnon and Artagaveytia-Allende (**1948**) and Georg (**1950** a, b) have proposed the consolidation of several of the species in this group. Because of the instability of the gross morphological characteristics by which the faviform trichophytons have been differentiated, Mackinnon and Artagaveytia-Allende suggested that the names *Trichophyton album*, *T. discoides*, and *T. ochraceum* were synonymous. Georg was able to prove this by demonstrating that single spore cultures could exhibit at one time or another all the gross morphological characteristics of each of these three "species," which she therefore reduced to varietal status. *Trichophyton faviforme*, the name selected by Georg to include these variants, has had considerable usage, but unfortunately is a nomen nudum and so a study was made to determine a valid name for this fungus in accordance with the International Rules of Botanical Nomenclature.

The facts are these. Sabouraud and his contemporaries were able mycologists and were more cautious in proposing new species than many of their successors. Their early findings clearly disproved the then prevailing view that there was only one trichophyton fungus, but as it was at first uncertain whether the different forms they recognized should be considered to differ specifically it was their custom to coin descriptive names, e.g. Trichophyton à culture rose, Trichophyton megalosporon pyogène du cheval, the primrose crater, etc. Subsequently, a number of these names were formally replaced by Latin binomials. Following this practice, Bodin (**1896** a, b, not Sabouraud as implied by Georg, **1950** b, p. 693) first proposed the group name "Trichophyton faviformes." As he wrote in 1902, ". . . j'ai donné le nom Trichophyton faviformes puis de favus à lesions trichophytoides pour indiquer que, si les lesions de ces champignons sur la peau sont en clinique et a l'examen microscopique absolument trichophytiques, les characters morphologiques de ces parasites sont tres analogues a ceux de l'Achorion Schoenleini" (Bodin, **1902**, p. 121–2).

Bodin recognized faviform trichophytons of the horse, the calf, and the ass and "Trichophytons faviformes" was subsequently unequivocably

used in a group sense by Gedoelst (**1902,** p. 94) and Guéguen (**1904,** p. 141) and by Sabouraud (**1910**) when he summarized his mature views in *Les Teignes.*

The first faviform trichophyton to receive a Latin binomial was that recovered from an ass, Trichophyton faviforme à culture grise (Bodin **1896** a), which was designated *Trichophyton verrucosum* by Bodin **1902**). Later Sabouraud proposed *T. album* and *T. ochraceum* (Sabouraud, **1908**), and *T. discoides* (Sabouraud, **1910**). More recently additional species have been proposed by Lebasque (**1933**) and others. Although Sabouraud formally proposed binomial names, he did in his 1908 paper and elsewhere sometimes use the terms "Trichophyton faviforme album," "Trichophyton faviforme ochraceum," etc. and these terms have been taken up as trinomials by some later authors. When *Trichophyton faviforme* was first used is uncertain. It has recently gained in popularity since its use by Skinner, Emmons and Tsuchiya (**1947**) and by Georg (**1950** a, b).

The importance of having names in line with the International Rules and in having names clearly typified needs no emphasis. Only when this is done is the application of names free from ambiguity. *Trichophyton faviforme* appears to be an appropriate name, but as it has never been validly published and is untypified its shortcomings must eventually become apparent. Further, it is now too late to validate the name, as it could not be maintained against earlier binomials. The simplest solution would appear to be to extend the scope of *T. verrucosum* Bodin, a name validly proposed and accompanied by an adequate description of a species which Bodin took to be typical of the *Trichophyton faviforme* group (Bodin, **1902,** p. 121).

The following new combinations are therefore made:

Trichophyton verrucosum Bodin var. **verrucosum.**
T. verrucosum Bodin (**1902**), p. 121.

Trichophyton verrucosum Bodin var. **album** (Sab.) Georg, comb. nov.
T. album Sabouraud (**1908**), p. 617.

Trichophyton verrucosum Bodin var. **ochraceum** (Sab.) Georg, comb. nov.
T. ochraceum Sabouraud (**1908**), p. 628.

Trichophyton verrucosum Bodin var. **discoides** (Sab.) Georg, comb. nov.
T. discoides Sabouraud (**1910**), p. 408.

The form of the name of the type variety is in line with the current Rules. It may also be noted that while *Trichophyton verrucosum* may

now be used in the wide sense, the various specific names: *T. verrucosum*, *T. album*, etc. are still available for use in their original senses by those who disagree with the taxonomic changes.

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LIPOMYCES STARKEYI ON THE SKIN SURFACE OF THE HUMAN BODY[1]

G. H. Connell, C. E. Skinner and R. C. Hurd

Lodder and van Rij (**3**) in 1952 created a new genus *Lipomyces* to include 5 cultures of non-fermenting yeasts in the Baarn-Delft collection. The first of these cultures was isolated from soil and named *Torula lipofera* in 1927 by den Dooren de Jong (**2**). It resisted all early attempts to induce sporulation. Later attempts by Lodder and van Rij were successful and the organism was renamed *Lipomyces lipoferus* (Door. Jong) Lod. & Rij, or more properly *Lipomyces lipoferus* Lod. & Rij, since the nomenclature of the imperfect stage has no bearing on the name of a perfect fungus. Ascospores, often more than 8, and possibly sometimes more than 16 in number, were produced in a sac-like protuberance from the mother cell, an unusual type of sporulation in yeasts which was described earlier by Starkey (**6**) in some soil yeasts, which he isolated and described but did not name. Three of Starkey's cultures along with one isolated from Canadian soil by Harmsen were placed in the new species, *Lipomyces Starkeyi* Lod. & Rij, which was designated the type species of the genus.

This present report concerns three new isolates of *Lipomyces Starkeyi* all of which were obtained from different human skin surfaces. Morphological characteristics including ascospore formation are those described by Lodder and van Rij for *Lipomyces* and with the yeasts isolated and described by Starkey (**6**). As far as can be ascertained this is the fourth record in the literature of isolation of any species of the genus and the first of any species of the genus from any source other than soil. Mrak and McClung (**5**) isolated a yeast from grapes which they called *Torulopsis*

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lipofera. Only the imperfect stage was found. Cultures are no longer available for study.

In the opinion of the authors, there is no valid reason for separating *L. lipoferus* from *L. Starkeyi,* since species determinations are based on the following rather questionable differential characteristics:

1. *Size of young cells.* Cell size range for *L. Starkeyi* is listed as 4–6.5 $\mu \times$ 5–8 μ versus 3.2–5 $\mu \times$ 5.7–9.3 μ for those of *L. lipoferus.*

2. *Lactose assimilation. L. Starkeyi* is described as being unable to proliferate in media with lactose as a sole source of carbon, while *L. lipoferus* is stated to have this ability.

3. *Alcohol utilization. L. Starkeyi* is quoted as "showing growth which is often weak" in a medium whose only carbon source is ethyl alcohol, while *L. lipoferus* is considered to be unable to grow in the same medium.

In reference to the size variation listed above, it should be noted that only a very limited number of isolates were actually measured, and the range of size variation comes well within the limits found in many species of yeasts. Moreover, even this much difference in size was found in only one medium and at one stage of growth. Isolates used to determine these measurements had been continuously under culture for periods ranging from six to twenty-five years, six years for *L. Starkeyi* cultures and twenty-five years for the culture of *L. lipoferus.* In the writers' experiments, careful and repeated testings of lactose and alcohol utilization by *L. lipoferus,* by use of methods developed by Wickerham (**7**), have resulted in the characteristics which Lodder and van Rij recorded for *L. Starkeyi.* The three new isolates from the body surfaces, like the type culture of *L. lipoferus,* which was obtained from Dr. Wickerham (who got it from Lodder), failed to grow with lactose as a sole carbon source, and two of the three new isolates, like the type strain of *L. lipoferus,* grew in a medium whose sole carbon source was ethyl alcohol. These are characteristics of the original description of *L. Starkeyi.*

In comparing the type culture of *Lipomyces lipoferus* and two of the three same Starkey strains of *L. Starkeyi* which Lodder studied, it was found that there was greater variation in the

morphology of the ascus between the two strains of *L. Starkeyi* than there was between *L. Starkeyi* and *L. lipoferus*. Starkey and Lodder and van Rij also noted the great variation between isolates in the number of ascospores. There would seem to be a much more fundamental difference between isolates of the same species than the comparatively trivial differences by which Lodder and van Rij would separate *L. Starkeyi* and *L. lipoferus*.

Since Lodder and van Rij have designated *L. Starkeyi* as the type species of a new genus of perfect fungi, it is apparent that the prior use of the specific epithet *lipoferus* for the imperfect stage only does not give a standing to *lipoferus* over *Starkeyi*. Hence, *Lipomyces Starkeyi* Lod. & Rij is the correct name if only one species is recognized (Sect. 11, Art. 69, International Code of Botanical Nomenclature).

By use of Wickerham's (**7**) carbon assimilation media and incubation up to four weeks, it was possible to show that all three of the new isolates of *L. Starkeyi* and also the "authentic" cultures of *L. lipoferus* and *L. Starkeyi* are able to produce "starch-like substances" from glucose. Lodder and van Rij (**3**), in their recent taxonomic treatise on yeasts, quite rightly, it is believed, have made "starch" production an important character in differentiating certain genera of imperfect yeasts. The fact that all the isolates of *Lipomyces* studied, including the type culture *L. lipoferus*, produce starch, may have some bearing on the phylogeny of some of the imperfect yeasts. It has been suggested (**4**, **1**) that *Cryptococcus* (in Lodder and van Rij's restricted sense), all species of which also produce starch, may have been derived from *Rhodotorula*. This concept would have to be abandoned or modified if it is established that *Cryptococcus* is derived from, or is the imperfect stage of, *Lipomyces*. Otherwise one would have to accept a polyphyletic origin for the genus *Cryptococcus*, which may well prove to be correct. Wickerham (**8**) has pointed out that some species of *Taphrina* also produce starch in culture and multispored asci on the host plant. He suggests the possibility "that species of *Lipomyces* are *Taphrina* which do not require a host for sporulation." He also calls attention to the physiological and morphological similarities of *Taphrina*, *Lipomyces* and *Cryptococcus*.

SUMMARY

1. Three cultures of *Lipomyces Starkeyi* were isolated from the skin of three different persons. These are the first isolations of any species of the genus recorded from a habitat other than the soil.

2. *Lipomyces lipoferus* Lod. & Rij is considered to be a synonym of *Lipomyces Starkeyi* Lod. & Rij.

3. All six cultures of *Lipomyces Starkeyi* studied (including the type strain of *L. lipoferus,* here reduced to synonymy with *L. Starkeyi*) produced a "starch-like" substance from glucose, like that produced by all species of the genus *Cryptococcus.* This might indicate a phylogenetic relationship between the perfect genus *Lipomyces* and the imperfect genus *Cryptococcus.*

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A NEW SPECIES OF STREPTOMYCES

C. W. Hesseltine,[1] J. N. Porter, N. Deduck, Marie Hauck, N. Bohonos and J. H. Williams

(with 1 figure)

Puromycin,[2] an antibiotic which is active against certain bacteria as well as the protozoan genus *Trypanosoma* (1), is produced by a species of *Streptomyces* heretofore undescribed. A culture of this species was isolated from a hardwood forest soil sample (pH 6.6) collected near Madison, Wisconsin.

DESCRIPTION

This new species of *Streptomyces* possesses a number of identifying characteristics, which distinguish it from other species of *Streptomyces*. A soluble pigment, olivaceous black according to Ridgway (2), is formed on some media such as asparagine dextrose agar, but there is no such pigment production on gelatin and certain other organic substrates. White spores are formed only on certain agars and then are often scantily produced. Growth is excellent on a synthetic medium containing mannitol as the sole carbon source. The growth pattern on asparagine dextrose agar proceeds from moist colorless colonies to yellow moist colonies to black moist colonies, which then produce the white aerial mycelium with spores. The colonies when growing under optimum conditions produce colorless droplets of moisture on the surface of the aerial mycelium. The optimum temperature for growth is 28–32° C. Spiral formation has not been observed.

Since the spore color is white as contrasted with the blackish pigment, the name *Streptomyces albo-niger* is being proposed for this species.

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[2] Puromycin is the chemical generic name of the antibiotic formerly called achromycin.

TABLE I

CULTURAL CHARACTERISTICS OF STREPTOMYCES ALBO-NIGER

Medium	Amount of growth	Aerial mycelium and spore color	Soluble pigment	Remarks
Asparagine dextrose meat extract agar	good	sporulation poor, growth white	black	colonies at 48 hours yellow with no pigment present; pigment begins to appear at 8 days.
Acid asparagine dextrose meat extract agar	poor	none	none	colonies moist and colorless.
Gelatin	fair	white aerial mycelium	light yellow	liquefaction slight to good; 30 mm. at 36 days.
Waksman's starch agar	good	white to pale olive buff or cartridge buff (Ridgway)	black	zones of hydrolysis 4–5 mm. in 14 days; clear, colorless droplets; sweet penetrating odor.
Emerson's agar	good	white—appears at 2 weeks	none	reverse yellow to tan.
Synthetic agar (Czapek's agar)	poor	white	none at 12 days	reverse white.
Potato plugs	excellent	white aerial mycelium abundant	dark, greenish black typically	colonies moist and yellow, later becoming white with aerial mycelium; colorless droplets on surface of colony.
Calcium malate plates	good	white	none, except at 1 month	reverse grayish white.
Nutrient agar	poor	none	none	colonies, moist smooth, and then of the color of the media.

TABLE I—*Continued*

Medium	Amount of growth	Aerial mycelium and spore color	Soluble pigment	Remarks
Glucose agar	poor	none	none	colonies moist, smooth, and then of the color of the media.
Litmus milk	poor—no pellicle	white	clearing of milk in upper portion of liquid	growth rings white above, then yellow green to light yellow brown and white below.
Krainsky's dextrose agar	fair to good	sl. white aerial mycelium	blackish gray	reverse blackish gray.
Potato dextrose agar	good to excellent	abundant white aerial mycelium	at 1 month a light brown pigment was seen	reverse light brown; colorless droplets on colony surface.
Bennett's agar	good	white to light gray	blackish brown	reverse dark brown.
Cellulose (filter paper in Czapek's solution)	none	—	—	—
Carrot plugs	excellent	white	none	—
Corn steep liquor	good	sl. white aerial mycelium	black	heavy mycelial growth but sporulation poor.
Sabouraud's maltose agar	excellent	white	black	aerial mycelium formed at about 2 weeks.

A more detailed description of the organism is given in TABLE I. All studies were made at room temperature or at 28° C, except where otherwise noted. In all cases the characteristics have been checked on agar plates or in test tube cultures several times and by two different laboratory groups. The Latin description was kindly prepared for us by Dr. D. P. Rogers of the New York Botanical Garden.

Streptomyces albo-niger sp. nov.

Incrementum in agaro cum asparagino dextrosoque composito bonum; sporulatio alba, nonnumquam guttulis hyalinis ornata, in agaris nonnullis, e.g. amylifero, cum pigmento solubili olivaceo-nigro; gelatinum liquificatum cum pigmento dilute luteo. Conidiophora irregulariter ramosa, haud helicis instar, ad 135 μ altitudine; conidia catenulata, paene globosa ad ovalia, 0.8–1.25 μ diam. Mannitol acceptum. Temperatura optima crescendo 28° C. E solo silvae deciduae cultivata: Madison, Wisconsin, Nov. 26, 1948.

When various carbon sources were substituted in Czapek's solution, *S. albo-niger* was found to use the following: mannitol, maltose, glycerol, dextrin, glucose, mannose, starch, and possibly lactose. Sucrose and xylose were not utilized. Of these carbon sources only glycerol, when incorporated in a nutrient basal medium, permitted a black soluble pigment to be produced. The morphology, determined microscopically on starch, Czapek, Bennett, and potato dextrose agars, is characterized by conidiophores, which reach a height of 135 μ and which are irregularly branched a short distance above the agar. The branches bearing the conidia are flaccid and flexuous on potato dextrose agar but shorter and erect on starch and Czapek agar. The catenulate conidia are oval and 0.8–1.25 μ in diameter (FIG. 1).

A study of the temperature requirements was carried out on asparagine dextrose agar; the results at the end of fourteen days being shown in TABLE II.

TAXONOMIC RELATIONSHIPS

In any study of the species within a genus one of the most important steps is the recognition of those stable characteristics which clearly define one species from another or one group of species from another. In *Streptomyces* a characteristic which may be of

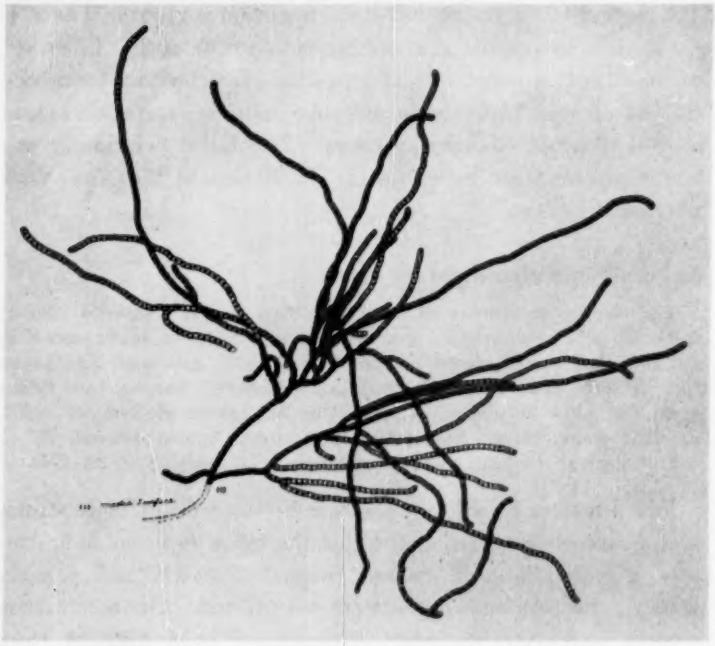

FIG. 1. Drawing of a portion of the aerial mycelium of *Streptomyces albo-niger* on synthetic agar. (Courtesy of Mr. A. A. Jansson.)

generic importance is the whorled arrangement of the fertile branches with the correlative characteristic of the conidia adhering together in chains, as is seen in *Streptomyes griseocarneus*. In addition to this whorled characteristic, the aerial spore color of the colony seems of great importance in separating large assemblages

TABLE II
GROWTH OF STREPTOMYCES ALBO-NIGER AT VARIOUS TEMPERATURES

Temp.	Growth	Aerial mycelium	Pigment	Surface color	Reverse color
24° C.	+	−	black	black above, yellow below	black
28° C.	+	white	black	black	black
32° C.	+	slight amount of white	slight black	white to yellow to brown	yellow to brown
37° C.	+	−	−	white	white

of species, such as the pink-spored group, the gray-spored group, etc. The white-spored forms, to which *S. albo-niger* belongs, comprise one of these major sections. It is obvious that this species is related to the chromogenic series and to *S. albus*. (Authentic type cultures of all the species mentioned here have been studied in our laboratory.) In the first section of *Streptomyces* in Bergey's Manual of Determinative Bacteriology (**3**), the only forms resmbling *S. albo-niger* are *S. albus* and possibly *S. verne*. *S. albus* produces little pigment and forms coiled chains of spores as contrasted with the heavily pigmented *S. albo-niger*, which does not show coiled spore chains. *S. verne* is usually described as being able to attack cellulose and to form an elm-green pigment on synthetic agar, but no mention is made of an olivaceous black pigment. *Streptomyces gougeroti* is similar to our culture with respect to the lack of pigment production in gelatin; it has white spores, sporulates on Emerson's agar without pigment production but does not produce a black pigment on such media as starch, asparagine, and other agars. It seems, therefore, that this culture, which we have named *S. albo-niger*, is unique. It is conceivable that it may represent an extreme form of one of the above species, but the lack of any observed intermediates among hundreds of white-spored isolates seems to rule out this theory.

It should be emphasized that this description is based upon the naturally occurring isolates and does not attempt to include natural or induced mutants or variants.

DIRECT MICROSCOPIC OBSERVATION

Another very important diagnostic characteristic in *Streptomyces* taxonomy is the determination of the aerial mycelium or conidiophore morphology. A method devised to study this in *S. albo-niger* and in other species of *Streptomyces* has been found to be very useful. Spores which are at least two weeks old are taken from the surface of colonies growing on solid media and then streaked on the surface of a suitable agar in Petri dishes. We

have found that a convenient agar to use is Czapek's agar with sucrose as the carbon source. On this medium the agar is transparent, thus permitting the ready transmission of the light required for microscopic study. At the same time, organisms which do not readily utilize sucrose grow sparsely, and the individual conidiophores are well isolated. After sufficient time for sporulation has occurred, the lid of the Petri dish may be removed, enabling one to study the aerial growth undisturbed under the low power objective of the microscope. Although the conidiophores are very small in diameter, by proper adjustment of light the aerial growth is outlined in such a manner that in a few minutes' time one can readily determine the general height, mode of branching, nature of spirals, etc. This dispenses with the elaborate procedure of fixing and mounting the material; a technique which usually shows only the separated individual elements without showing their relationship to each other. The only justification for the use of the latter method in the taxonomy of *Streptomyces* is to determine spore shape and size; however, these latter characteristics are of little importance in classifying species of *Streptomyces*. The only other characteristic which should be determined is whether the spores are in chains or not; and, if they are in chains, whether the spores readily separate in water. The spores of certain species such as *S. griseocarneus* do not easily separate in water; however, even this characteristic is correlated with the whorled arrangement of the fertile branches; a fact which can be determined by the above procedure.

SUMMARY

A new species of *Streptomyces, S. albo-niger,* which produces the antibiotic puromycin, has been described. Its taxonomic relationships are discussed, as well as a simple, direct method of studying the morphology of the aerial growth of it and other Streptomyces.

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THE TOXICITY OF CERTAIN SPECIES OF AMANITA TO GUINEA PIGS

KIKI FRERET COOK [1]

Amanita muscaria Fr., *A. phalloides* Fr., and *A. verna* Fr. are the species most often responsible for cases of mushroom poisoning. Muscarine, the chief toxic constituent of *A. muscaria,* was first isolated in 1869 by Schmiedeberg and Koppe (**5**), and has also been shown to be present in *A. pantherina* Fr. (**12**).

The presence of a hemolytic substance in *A. phalloides* was first demonstrated by Kobert in 1891 (**3**). Ford (**3**) prepared extracts of *A. phalloides* which exhibited hemolytic activity against the erythrocytes of rabbits, guinea pigs, dogs, and man. The hemolytic properties of these extracts were irreversibly destroyed by exposure for 30 minutes to a temperature of 65–70° C. Because of its thermolabile character, the hemolysin of *A. phalloides* can be of little significance in mushroom poisoning in cases where cooked mushrooms are eaten.

Since extracts of *A. phalloides* which had been heat treated to inactivate the hemolysin proved to be extremely toxic to guinea pigs and rabbits, Ford (**4**) demonstrated the presence of a second more thermostable principle, to which he gave the name Amanita-toxin. Abel and Ford (**1**) found it possible to separate the hemolysin from the toxin by means of ethyl alcohol as well as by heat treatment; the toxin being soluble in alcohol, while the hemolysin was precipitated. Further studies of the chemical nature of the Amanita-toxin have been made by Ford and Bronson (**9**) and Wieland and Witkop (**15**).

Ford (**3**) summarized the pathological changes induced by *A. phalloides* poisoning as including the absence of postmortem rigid-

[1] From a thesis presented to the Graduate School of Vanderbilt University in partial fulfillment of the requirements for the degree of Master of Arts, August, 1952. The writer wishes to express her appreciation to Dr. Frederick T. Wolf under whose direction this work was done.

ity; a bright cherry-red color of the blood, which fails to coagulate; hemorrhages in the serous membranes and parenchymatous organs; necrosis and fatty degeneration of the liver, kidneys, heart and muscles; and distention of the bladder with urine. The experiments of Ford (**4, 6**) in which animals were injected with the whole extract of *A. phalloides,* or with the hemolysin alone or with the toxin alone indicated that hemoglobinurea and deposition of pigment in the spleen were attributable to the hemolysin. The production of ulceration of the stomach and intestine, hemorrhage, necrosis of tissue, and fatty degeneration of the liver were shown to be due to the Amanita-toxin.

Ford (**7, 8**) and Ford and Sherrick (**10**) determined the presence or absence of Amanita-toxin in a number of species of *Amanita* by injection into animals of extracts heated to destroy the hemolysin. *A. verna* Fr., *A. virosa* Fr., *A. spreta* Pk., *A. strobiliformis* Vitt., *A. radicata* Pk., *A. chlorinosma* Pk., *A. porphyria* Fr., *A. morrissii* Pk., *A. citrina* Roques, *A. crenulata* Pk., and *A. mappa* Fr. were shown to be toxic. Non-toxic species were *A. rubescens* Fr., *A. solitaria* Fr., *A. frostiana* Pk., *A. russuloides* Pk., and *A. pantherina* Fr.

In attempting to produce poisoning of animals by *A. phalloides,* Ford (**6**) found that rabbits were apparently immune to extracts of this fungus when administered by mouth. 10 cc of an extract, 0.25 cc of which would kill a rabbit when injected subcutaneously, was administered orally to a number of rabbits without ill effect. The reason for this unexpected result has never been explained. In discussing it, Ford (**8**) states: Toxicity "must be established by subcutaneous or intraperitoneal injection, feeding experiments with fungi, as a rule, giving us little information of value. Indeed there is considerable evidence to show that the herbivora may be entirely insusceptible to the action of the most virulent of the poisonous species when these are introduced into the stomach. Substances poisonous to animals on inoculation may, however, be quite harmless to man on ingestion, being split up into non-toxic products by the various digestive juices or for unknown reasons not being absorbed by the mucous membrane of the intestinal tract. We can not conclude therefore that species which kill animals by our method of administration are necessarily harmful to man when

eaten. Nevertheless we know that a number of fungi . . . have a definite toxicity for animals, and if we compare the action of unknown species with them we may ascertain something of their properties and hazard an opinion as to the probable effect of their consumption by man."

In addition to *A. phalloides, A. verna,* and *A. muscaria,* Kauffman (**13**) lists *A. bisporigera* Atk., *A. spissa* Fr., *A. mappa* Fr., *A. spreta* Pk., and *A. virosa* Fr., among the poisonous species. Various authorities are not always in agreement concerning the poisonous properties of certain species. This confusion may be exemplified by *A. chlorinosma,* which is listed by Kauffman (**13**, p. 615) as "edible, but use caution." In this same volume, p. 837, in a section written by O. E. Fischer, *A. chlorinosma* is regarded as "probably seriously poisonous."

The difficulties in determination of the toxicity of fungi include uncertainties as to species identification, variation in toxin content within a species, difficulties in extraction of the toxic component, and the nature of the test which is used. Apparently little work of an experimental nature has been done with the toxicity of Amanitas since the studies of Ford and his co-workers. It is the purpose of this paper to report the results obtained in animal experiments with a number of *Amanita* species, following the techniques of Ford.

MATERIALS AND METHODS

Ten species of *Amanita* were studied. The material of *A. chlorinosma* Pk. was collected and identified by Frederick A. Wolf, Durham, N. C., in 1951. *A. verna* Fr. was collected and identified by Frederick T. Wolf, Pleasant View, Tenn., July 1, 1950. *A cothurnata* Atk., *A. flavivolva* Murr., *A. mutabilis* Coker, *A. neglecta* Murr., *A. praegraveolens* Murr., *A. roanokensis* Coker, *A. verniformis* Murr. and *A. virosiformis* Murr. were collected and identified by Dr. W. A. Murrill, Gainesville, Florida.

Alcoholic extracts of each of these fungi, with the exception of *A. chlorinosma* and *A. verna,* were prepared by grinding 5 gm of the dried fungi with a mortar and pestle, adding 30 cc of 65% alcohol, extracting under refrigeration for 72 hours, and filtering

with a Mandler filter. Because of the limited amount of material available, the extract of *A. chlorinosma* contained only 4.2 gm of fungus in 30 cc of 65% alcohol, and that of *A. verna* contained 2.2 gm. The extracts were stored in a refrigerator during the time between their preparation and use. 65% alcohol was chosen as the solvent since Ford and Bronson (**9**) had found that Amanita-toxin is highly soluble in alcohol of this concentration.

Guinea pigs were chosen as experimental animals. All were young females. Two of the animals were large, weighing approximately 760 gm, while the remaining animals were smaller, averaging 300 gm each.

Injections of the extracts were made subcutaneously, with a hypodermic syringe, either on the inner surface of the hind leg, or on the abdomen. Aseptic technique was used. The quantity of extract injected ranged from 0.5 cc to 2.0 cc. In the case of each species of *Amanita* tested, two animals were used. A control was provided by injection of 65% alcohol alone.

The animals were observed for symptoms of poisoning after receiving an injection. In the case of animals which died, an autopsy was performed, and the gross pathological changes were noted.

RESULTS

The results of these experiments are presented in TABLE I.

In many instances, the animals developed abscess-like lesions at the site of inoculation.

Both animals receiving injections of *A. verna* died within forty-eight hours. The first symptoms of poisoning were observed in about twenty-four hours after injection, at which time the animals remained huddled in a corner of the cage with their eyes closed and their fur ruffled. Handling appeared to produce some discomfort. Autopsy disclosed a lack of post mortem rigidity, failure of the blood to coagulate, and extensive pin-point hemorrhage of the liver. The gall bladder was filled with a blood-stained fluid, and the bladder was distended with unstained urine. The spleen displayed ecchymoses, and the intestinal mesenteries were filled with clear fluid. There was extensive hemorrhage of the outer wall of the cecum and the large intestine. The contents of

the stomach were bloody, and both the inner and outer walls were hemorrhagic.

Both animals receiving *A. verniformis* died, one within twenty-four hours and one within forty-eight hours. Within ten minutes after the injection, both animals were found in a dazed condition, unable to stand or move. This condition cleared up within a few hours in one animal, but the other remained unable to move its

TABLE I

THE RESULTS OF SUBCUTANEOUS INJECTION OF 65% ALCOHOLIC EXTRACTS OF TEN SPECIES OF AMANITA INTO GUINEA PIGS

Species	Dosage	Result
A. chlorinosma	1.5 cc	No effect
A. chlorinosma	1.5 cc	No effect
A. cothurnata	2.0 cc	No effect
A. cothurnata	2.0 cc	No effect
A. flavivolva	2.0 cc	No effect
A. flavivolva	2.0 cc	No effect
A. mutabilis	1.5 cc	No effect
A. mutabilis	1.5 cc	No effect
A. neglecta	1.5 cc	No effect
A. neglecta	1.5 cc	No effect
A. praegraveolens	1.5 cc	No effect
A. praegraveolens	1.5 cc	No effect
A. roanokensis	1.5 cc	No effect
A. roanokensis	1.5 cc	No effect
A. verna	1.5 cc	Died within 48 hours
A. verna	0.5 cc	Died within 48 hours
A. verniformis	1.5 cc	Died within 24 hours
A. verniformis	1.5 cc	Died within 48 hours
A. virosiformis	1.5 cc	Died within 30 hours
A. virosiformis	1.5 cc	Died within 30 hours
Control—65% alcohol	1.5 cc	No effect

hind quarters. No other ill effects were manifested until twenty-four hours later when the animals were found prostrate in the cages. Respiration was rapid and shallow. Approximately two hours before death the animals suffered a succession of convulsive seizures of the extremities. Autopsy findings included post mortem rigidity in one case, with lack of rigidity in the other, petechial hemorrhages of the liver, failure of the blood to coagulate, distention of the bladder with unstained urine, and hemorrhage of the inner wall of the stomach.

The animals receiving *A. virosiformis* died within thirty hours after injection. They exhibited no symptoms of poisoning during the first twenty-four hours, but after this period of time became

inactive and remained huddled with ruffled fur in the corner of the cage. Autopsy findings were post mortem rigidity, pin-point hemorrhages of the liver, and failure of the blood to coagulate. The gall bladder was filled with a red-stained fluid, and the bladder was distended with unstained urine.

No symptoms were noted in the case of animals injected with extracts of *A. chlorinosma, A. cothurnata, A. flavivolva, A. mutabilis, A. neglecta, A. praegraveolens,* or *A. roanokensis,* or in a control animal which received 65% alcohol.

DISCUSSION

The techniques employed in this study differ in a number of details from those employed by Ford and his collaborators, who used aqueous extracts in some instances and alcoholic extracts in others. Ford generally heated the extracts to 65–70° C for one-half hour to destroy the hemolysin, while the extracts used in this study were not heated. In the present experiments the hemolysin should not have been present in the extracts made with 65% alcohol (**9**).

Of the species studied, *A. verna* is commonly regarded as deadly poisonous (**13, 11, 14**). Ford (**7**) found *A. chlorinosma* to be poisonous, and to contain in small quantities a poison practically identical with Amanita-toxin, while Hesler (**11**) notes its edibility as doubtful. *A. cothurnata* is regarded as probably poisonous by Atkinson (**2**), suspect by Kauffman (**13**) and by Hesler (**11**), and poisonous by Krieger (**14**), although no experiments with this species in animals have been found. No information has come to the writer's attention concerning the edibility or toxicity of the remaining species studied.

The present experiments indicate that *A. verna, A. verniformis,* and *A. virosiformis* are toxic to guinea pigs, while *A. chlorinosma, A. cothurnata, A. flavivolva, A. mutabilis, A. neglecta, A. praegraveolens,* and *A. roanokensis* are not toxic to this experimental animal. Thus, the findings concerning *A. chlorinosma* and *A. cothurnata* are at variance with the results of other workers.

The autopsy findings in the animals which died following administration of *A. verna, A. verniformis,* and *A. virosiformis* indicate

that failure of the blood to coagulate, pin-point hemorrhage of the liver, hemorrhage of the intestinal tract, and anuria were common to all animals. The evidence thus strongly favors the presence of Amanita-toxin in all three species. The rapid onset of symptoms and paralysis produced in animals injected with extracts of *A. verniformis* suggests the presence in this species of some additional toxic agent acting upon the central nervous system.

SUMMARY

This investigation is concerned with the determination of the toxicity of a number of species of *Amanita* to guinea pigs.

Alcoholic extracts of *A. chlorinosma, A. cothurnata, A. flavivolva, A. mutabilis, A. neglecta, A. praegraveolens,* and *A. roanokensis* were injected subcutaneously into guinea pigs without the appearance of any symptoms. It is concluded that these species are not-toxic by this method of testing.

Alcoholic extracts of *A. verna, A. verniformis,* and *A. virosiformis* were injected subcutaneously into each of two guinea pigs, resulting in the death of both animals in each case within forty-eight hours. Autopsies were performed upon these animals, and the gross pathological changes noted include failure of the blood to clot, hemorrhage of the intestinal tract, anuria, and extensive pin-point hemorrhages of the liver.

The symptoms indicate the presence of *Amanita*-toxin in each of these species. The rapid onset of symptoms and paralysis noted in the animals injected with *A. verniformis* suggests the presence in this species of an additional toxic principle affecting the central nervous system.

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EFFECT OF LIGHT ON COLOR IN DACRYMYCES

THOMAS J. BULAT

The color of *Dacrymyces Ellisii* in the field varies from yellow to deep orange. In view of the fact that importance is often placed on the color of a specimen in its identification, the nature of this color difference poses an interesting problem. In studying this problem light-exposure tests were made with *Dacrymyces Ellisii*. Cultural forms of this fungus were used because of the obvious difficulty encountered in obtaining data from specimens growing in the field.

The cultural forms of *Dacrymyces Ellisii* were described in an earlier paper (**1**). Since the publication of that paper, an important reference to the cultural forms of the tremellaceous fungi by Yen (**3**) has been noted. Although Yen's paper is concerned with the sexuality of the fungi, it also reports interesting results from the culture of several members of the Tremellales. Most noteworthy of these is the culture of *Calocera cornea* in which the author reports the occurrence of irregular fruiting bodies which produce many conidia and a few basidia. This is the only report of basidia of any tremellaceous fungus produced in culture.

The nature of the pigmentation of *Dacrymyces Ellisii* was reported in a note by Hanna and Bulat (**2**).

EFFECT OF LIGHT INTENSITY AND DURATION

Single point inoculations were made on plates of malt agar. The inoculated plates were placed in darkness for a period of 15 days at room temperature, at the end of which time they were whitish to pale buff. At this time they were exposed to light of varying intensity for periods of from ten minutes to ten days. Recordings were made of the color of the colonies at the end of exposure to light. The plates were again placed in darkness for another ten days, and the color at the end of this time was also

recorded. Ten plates were used for each separate time of exposure. Controls consisted of cultures in complete darkness from time of inoculation until the termination of the experiment, and cultures which were exposed to the light for the entire experiment. Two light intensities were used: 50 f. c. and 100 f. c.

RESULTS

The results are graphically described in TABLES I, II, III and IV. The experiments showed that an increase in light intensity caused the pigment to be produced at a faster rate, but that at the end of the experiment those colonies exposed to both intensities were of approximately the same color.[1] TABLE I represents cul-

TABLE I

50 f. c.

Time exposed to light	Color at end of exposure [1]	Color after 10 days in dark
10 min	White to light buff	No color change
12 hrs	White to light buff	No color change
1 day	Light pinkish cinnamon	No color change
2 days	Apricot buff	No color change
3 days	Orange buff	No color change
4 days	Capucine orange	No color change
5 days	Capucine orange	No color change
6 days	Capucine orange	No color change
7 days	Capucine orange	No color change
8 days	Mikado orange	No color change
9 days	Mikado orange	No color change
10 days	Mikado orange	No color change
Controls		
0 days (dark)	White to light buff	
35 days (light)	Orange	

[1] Final colonies in all experiments were surrounded with a white band representing growth during the 10 days period in darkness where no pigment was formed.

tures exposed to 50 f. c. Maximum color was obtained in 8 days. TABLES II, III and IV represent cultures exposed to 100 f. c. Maximum color was obtained in 3, 3½ and 4 days respectively.

The length of time necessary for a particular color to be reached varied in experiments which were subjected to similar light in-

[1] Colors were determined with the aid of Ridgway's "Color Standards and Color Nomenclature," 1912.

tensities. The cultures listed in TABLE II and TABLE III were subjected to 100 f.c.; yet in the cultures of TABLE II the color light orange yellow was obtained at the end of 24 hours; in the cultures listed in TABLE III this same color was not obtained until 48 hours.

All experiments represented by the tables were done at separate times. At any one particular light intensity and duration of ex-

TABLE II

100 f. c.

Time exposed to light	Color at end of exposure [1]	Color after 10 days in dark
5 min	White to light buff	No color change
1 hr	White to light buff	No color change
6 hrs	Light buff to warm buff	No color change
12 hrs	Pale yellow orange	No color change
24 hrs	Light orange yellow	No color change
1½ days	Light orange yellow	No color change
2 days	Light orange yellow	No color change
2½ days	Deep chrome	No color change
3 days	Cadmium yellow	No color change
4 days	Cadmium yellow	No color change
5 days	Cadmium yellow	No color change
Controls		
0 days (dark)	White to light buff	
30 days (light)	Cadmium yellow	

TABLE III

100 f. c.

Time exposed to light	Color at end of exposure [1]	Color after 10 days in dark
12 hrs	Light buff	No color change
1 day	Pale orange-yellow	No color change
1½ days	Pale orange-yellow	No color change
2 days	Light orange-yellow	No color change
2½ days	Deep chrome	No color change
3 days	Deep chrome	No color change
3½ days	Cadmium yellow	No color change
4 days	Cadmium yellow	No color change
4½ days	Cadmium yellow	No color change
5 days	Cadmium yellow	No color change
Controls		
0 days (dark)	White to light buff	
30 days (light)	Cadmium yellow	

TABLE IV

100 f. c.

Time exposed to light	Color at end of exposure [1]	Color after 10 days in dark
12 hrs	Light buff	No color change
1 day	Pale yellow orange	No color change
1½ days	Pale yellow orange	No color change
2 days	Orange buff	No color change
2½ days	Capucine yellow	No color change
3 days	Capucine yellow	No color change
3½ days	Capucine yellow	No color change
4 days	Orange	No color change
4½ days	Orange	No color change
5 days	Orange	No color change
Controls		
0 days (dark)	Light buff	
30 days (light)	Orange	

posure, there was no variation in color within the same experiment. However, when various experiments were compared, variation of color did occur. The final color of colonies listed in TABLE II was cadmium yellow; while at the same intensity and duration of exposure, the final color of the colonies listed in TABLE IV was orange. This point is also brought out by the fact that in the colonies listed in TABLE I the colors light pinkish cinnamon and apricot buff were encountered. These colors were not observed in any of the other experiments.

An attempt was made to standardize the conditions for all experiments represented in the tables. However, no constant temperature was maintained and slight variations may have occurred in the media which were prepared in separate lots over a period of several months. This may explain the minor color differences encountered at coinciding points in the various experiments.

CONCLUSIONS

1. The pigment did not form in the dark.

2. In colonies subjected to a period of light followed by a period of darkness, a colorless band formed indicating the amount of growth during the period of darkness.

3. Once the pigment was formed, the colonies did not lose color on being replaced in darkness; they kept their maximum color until agar in the petri dishes began to dry up.

This work was done under the supervision of Professor G. W. Martin.

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ASCOCYBE, A NEW GENUS OF LOWER ASCOMYCETES [1]

DOREEN E. WELLS [2]

(WITH 14 FIGURES)

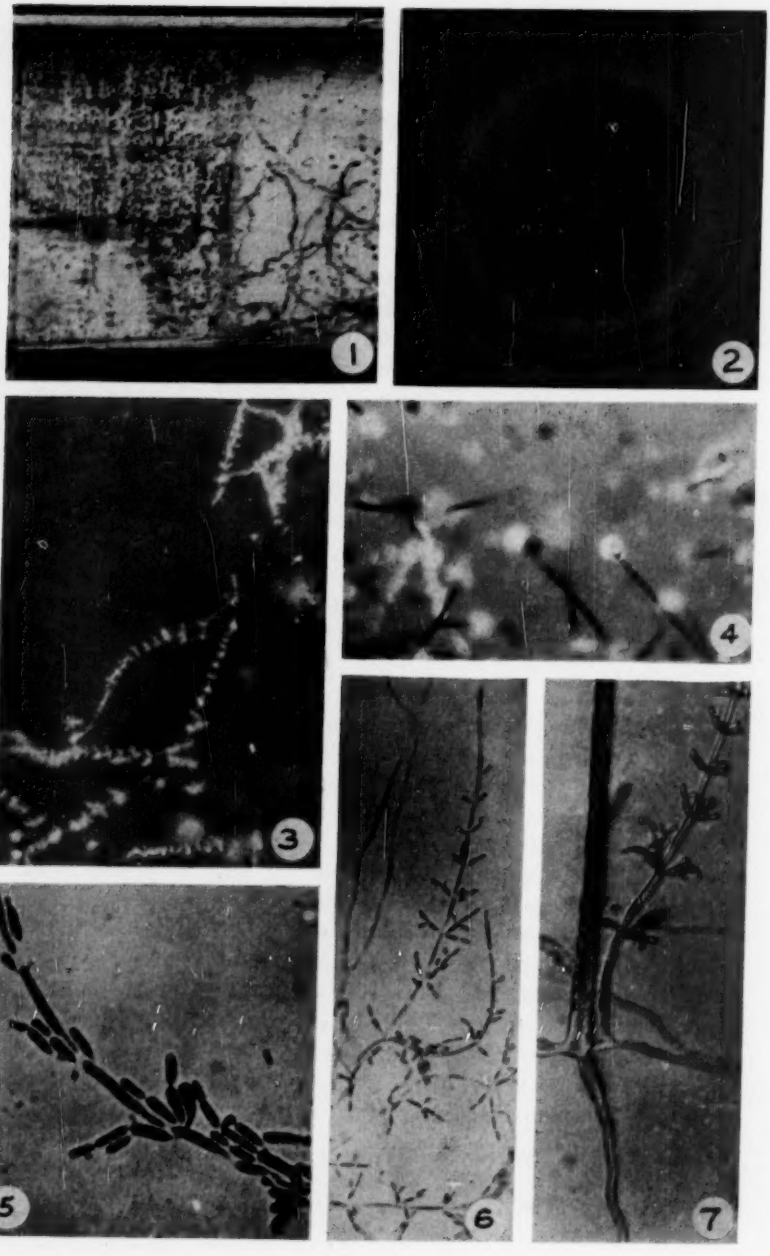
In the course of a study of a series of cultures isolated from wood, a fungus was encountered in 1950 which proved to be of very special interest. On superficial examination, the fungus suggested a *Haplographium* or *Leptographium* because of the mass of spores immersed in mucus borne at the apex of an erect, brown, specialized hypha. Critical examination, however, revealed that this was not a hyphomycete, but an ascomycete of an unusual type. At the apex of this specialized hypha are produced naked asci which proliferate to form a complex head. The ascospores are of the characteristic bowler-hat shape found in many other lower forms.

The first cultures of the organism to be received were from British Columbia, isolated from wood of *Pseudotsuga taxifolia* (Poir.) Britton and *Tsuga heterophylla* (Raf.) Sarg. Shortly afterwards, an isolation made from cut lumber of *Pinus strobus* L. in a lumber yard at Tee Lake in the Ottawa valley was also received. The three cultures varied little except that the last produced the most luxuriant growth.

Further investigation has shown that the fungus is of common occurrence in all white pine storage yards throughout the Ottawa valley, where it has been known for years as a brown surface growth which disfigures the cut lumber, and has been called "brown surface stain." Damp weather makes it especially troublesome, for then it spreads easily to adjacent boards, usually over the sapwood, and affects many boards in a pile. Judging from some growth patterns on the wood, it is quite possible that insects contribute to the dissemination of the fungus (FIG. 1). Treatment with Permatox, a product containing sodium pentachlorophenate, which is commonly used to check the growth of blueing fungi, is of little value in controlling this fungus. Apparently this organism does not cause any deterioration of the wood, and the superficial discoloration can readily be removed by planing.

[1] Contribution No. 1275 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

[2] Assistant Mycologist, Central Laboratory, Ottawa.



FIGS. 1–7.

A number of systems of classification have been proposed in the literature for the group known as the lower Ascomycetes, as seen in Gaumann and Dodge (**1928**), Clements and Shear (**1931**), Dodge (**1935**), Gwynne-Vaughan and Barnes (**1937**), Wolf and Wolf (**1947**) and Bessey (**1950**). In a standard classification, such as the one given in Wolf and Wolf, those fungi which produce asci singly or in groups on the mycelium without producing an ascocarp are found in the Endomycetales (Saccharomycetales), which is further subdivided into three families, the Ascoideaceae, the Endomycetaceae, and the Saccharomycetaceae. The first-named family comprises forms which produce multispored asci. The fungi in both the second and third families produce asci with eight or fewer spores, but differ with respect to the amount of mycelium produced. The Endomycetaceae have a well-developed mycelium, the Saccharomycetaceae produce it only sparingly or not at all.

A survey of the forms described in the Endomycetaceae has shown them to be of a simple or reduced type and lacking in a specialized ascus-bearing hypha such as the one mentioned above belonging to this fungus. Since this is a special structure, bearing asci, it is proposed to refer to it as the ascophore. The only objection to this might lie in the fact that the term is already being used for the ascogenous hyphae of an ascocarp, or the ascocarp itself. This, however, should cause no confusion since in every case the intended meaning should be quite clear from the context.

Notwithstanding its strikingly different morphology, which might, in the more conventional classifications, require the establishment of a new family, there are reasons for considering this fungus to be closely related to other forms among the lower Ascomycetes. Zender (**1925b**) suggested that the hat-shaped or cucullate ascospore might form the basis for a natural classification. He considered this spore type to be of fundamental importance in indicating relationships, and, consequently, brought together in the genus *Endomyces* many simple and reduced forms which all produce this type of spore. The genus would then include forms in which the asci occur terminally on the mycelium, in the intercalary cells, or in separate cells, and produce from one to four spores per ascus.

FIG. 1. *Ascocybe* growing on a white pine board from lumber pile. Growth at left occurred beneath a "crosser"; growth pattern at right suggests insect dissemination. 2. Colony on malt extract agar. Actual size after 20 days. 3. Conidiophores and young ascophores at edge of colony, × 60 approx. 4. Mature ascophores, × 60 approx. 5. Part of conidiophore, × 930 approx. 6. Conidiophores showing terminal budding cells, × 375 approx. 7. Conidiophore and ascophore arising from same hypha, × 410 approx.

It is considered that the presence of the ascophore found in the fungus under discussion will require that it be maintained as a separate genus from *Endomyces*. It will therefore be necessary to erect a new genus and species to receive this new form. Because the fungus produces a head of asci, the name *Ascocybe*, which was kindly suggested by Mr. E. W. Mason of the Commonwealth Mycological Institute, is considered descriptive of the fungus and is hereby applied to it.

DESCRIPTION

Ascocybe gen. nov.

Ascocarpium deest. Asci generantur ex apice ascophori et proliferant in capitem ascorum; ascosporae cucullatae.

Ascocarp lacking; asci budding from the apex of an ascophore and proliferating to form a head of asci; ascospores cucullate.

Ascocybe grovesii sp. nov.

Ascocarpium deest; mycelium vegetans hyalinum, septatum, ramosum, 1.2–2.5 μ diam., gaudet ascophoris erectis 200–700(–900) μ alt., 6.0–9.5(–12) μ diam., basi summoque hyalinis, cetero brunneis et incrustatis, 3–8(–12)-septatis, basi nonnunquam gaudens ramis rhizoideis; asci generantur ut gemmae apicale ascophororum et proliferant in capitem ascorum, asci insuper ellipsoidei, tetraspori, ephemeri, pariete tenuissimo hyalino, 4.4–6.6(–15) × 2.5–3.1(–4.5) μ; ascosporae cucullatae, hyalinae, unicellulares, 2.5–3.3 × 1.8–2.5 μ, liberatae sunt, ascis desintegrantibus, et congregant in mucoso capite; conidiophori ascendentes, hyalini, septati, fragiles, longitudine variabiles, cellulis 15–30 × 1.2–2 μ; conidia hyalina, unicellularia, a cylindricis ellipsoideo-ovoidea, 3–9.5(–12.5) × 1–2.5 μ, verticillata, orientia ut gemmae ex apice distali cellularum successivarum axialium, deinde iterum gemmigerantia gaudent verticilli compositis.

Ascocarp lacking. Vegetative mycelium hyaline, septate, branched, 1.2–2.5 μ in diam. producing erect ascophores 200–700(–900) μ in height, 6.0–9.5(–12) μ in diam., hyaline at base and apex, elsewhere brown and encrusted, 3–8(–12)-septate, at the base often forming rhizoidal branches; asci arising as buds from the apex of the ascophore and proliferating to form a head of asci, ellipsoid, four-spored, ephemeral, with thin, hyaline wall, 4.4–6.6(–15) × 2.5–3.1(–4.5) μ; ascospores cucullate, hyaline, unicellular, 2.5–3.3 × 1.8–2.5 μ, released by the disintegration of the asci and accumulating in a mucous head; conidiophores ascending, hyaline, septate, fragile, variable in length, the cells 15–30 × 1.2–2 μ; conidia hyaline, unicellular, cylindrical to ellipsoid-ovoid, 3–9.5 (–12.5) × 1–2.5 μ, verticillate, arising as buds from the distal apex of successive axial cells, then budding again into compound verticils.

Habitat: Dressed lumber of *Pinus strobus* L. Wood of *Tsuga heterophylla* (Raf.) Sarg., *Pseudotsuga taxifolia* (Poir.) Britton, and *Picea sitchensis* (Bong.) Carr.

Type: DAOM *33766*. *Pinus strobus* L. Braeside, Ontario. November 24, 1952.

Specimens examined: CANADA: **British Columbia**: Copper Canyon, DAOM *29115;* **Ontario**: C.M.I. No. *1493;* Tee Lake, DAOM *29116;* Braeside, DAOM *33766*.

In addition to the specimens cited above, I have been informed by Mr. E. W. Mason (in litt.) that he has examined a culture of the same fungus isolated from *Picea sitchensis* at the Forest Products Research Laboratories, Princes Risborough, England.

CULTURAL CHARACTERS

When single ascospores are isolated they germinate in from two to eight hours. Mature conidiophores are produced in 24 hours, and in three days the perfect state is present in a sporulating condition. It is concluded, therefore, that the fungus is homothallic.

The fungus grows well in culture on sugary organic media such as malt extract, potato dextrose, prune and onion agars. Pine infusion agar and plain agar with sugar added also produce very good growth. Starchy media which do not contain sugar are not satisfactory. The fungus matures well on moist filter paper, but on synthetic media such as Czapek's and nutrient agar, even with the addition of sugar, growth is poor and atypical.

The culture medium used throughout this study was 2% malt extract agar, chosen because of its general use and because good growth was obtained on it. At room temperature, on this medium, the rate of growth is about 1.1 cm in 10 days. The young colony is at first entirely white due to the presence of the conidial state, but turns buff, then Cinnamon Brown [3] to Auburn [3] after some days. A characteristic odour is produced which, in the young colony, is at first fruity, becoming winy, then yeasty or musty in old cultures.

Examination of a young colony under the dissecting microscope reveals that the brown coloration is due to the presence among the white aerial conidiophores of the brown ascophores (FIGS. 3, 4). These structures arise from the same hyphae that produce the conidiophores (FIG. 7), but require several days to reach maturity. They then appear in regular succession behind the conidiophores as the radiating hyphae

[3] Ridgway, R. Color Standards and Color Nomenclature. Washington. 1912.

produce a fan-like growth over the agar. Aerial vegetative mycelium is very scant or lacking. In several days the culture is usually minutely-velvety, brown in color, and surrounded by a narrow white border (FIG. 2). The ascospores may coalesce into slimy masses in a luxuriantly-growing colony. When growth has continued for some weeks on a plate, the fruiting structures usually become less abundant at the periphery of the colony, giving the culture a fine, downy appearance. This scantier growth may be correlated with a reduction of the sugars remaining in the agar.

CONIDIAL STATE

As noted above, the first fruiting structures produced in a young culture are the conidiophores with the conidia. These have a very characteristic appearance. The conidiophore consists of a central axis of cells produced in acropetal succession, and is of indeterminate length. The cells of the axis are long and narrow and loosely held together at the septa, thus resembling oidia. The conidia arise as buds at the upper end of these cells, and are produced in whorls that may become branched in a complex manner. Because of the indeterminate type of growth of the conidiophore, the basal whorls are found to have the most extensive ramification and the largest number of conidia. This ramification is made possible by the conversion of a conidium to a branch cell, which in turn produces a new whorl of conidia. In this way, three to five orders of branching are often found in the basal whorls. Similarly, the number and size of the conidia decrease in each whorl towards the tip of the conidiophore thus giving rise to a tapered appearance (FIG. 6).

This method of growth may result in conidiophores having 20 or so whorls, although most of them produce a lesser number (FIG. 3). In the older parts of the culture, the conidiophores lose their delicate, branched appearance due to their collapse and the conglutination of their spores.

The conidiophores bear a resemblance to those of *Cladosporium* in their fragility and branching, and, like them, readily disintegrate if disturbed. When mounted, the isolated cells are found to be of various shapes and sizes depending on age and location upon the conidiophore (FIGS. 5, 6). The cells which form the axis of the conidiophore usually are the longest and have several short projections at one end to which the conidia were attached. The branch cells are hardly distinguishable from the axis cells except in being slightly shorter and broader. The axis cells usually are within the range 15–30 μ long, by 1.2–1.9 μ wide; the branch

cells are from 7–12.5 by 1.9–2.5 μ, and the conidia from 3.1–9.3 by 1–2.5 μ with some overlapping in size between branch cells and conidia.

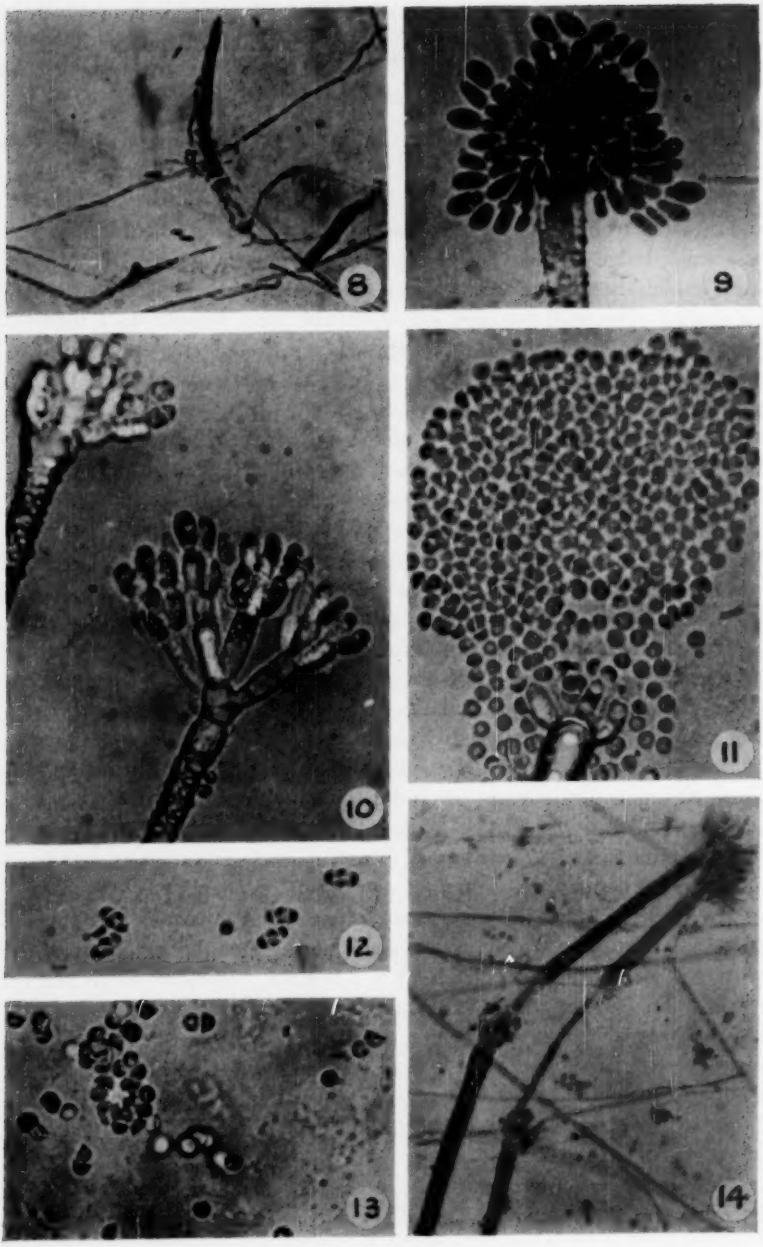
PERFECT STATE

The development of the perfect state can be followed in detail from an examination of the hyphae in a one- to two-day old culture. The hyphae which give rise to the ascophores are slender, hyaline, and septate, and measure from 1.2–2.5 μ in diameter. The ascophore is first observed as a small bulge on the wall of the hypha. This bulge soon becomes a stout branch that grows upward from the substratum and becomes septate (FIG. 8). The wall becomes yellowish and then deepens to a medium brown, at the same time becoming roughened and encrusted with irregularly-shaped, brown particles (FIG. 10). It was noted that when a cover-glass culture was made of the fungus, the ascophores remained hyaline until they had grown beyond the edge of the cover glass, and then abruptly turned brown. The apex of the ascophore remains hyaline and thin-walled. The base of the ascophore also lacks coloration, and in this area one to several hyaline, root-like processes appear, probably serving as anchorage and perhaps absorbing nourishment (FIG. 7). A typical ascophore just before ascus formation begins has from 3 to 6 septa, is 6–10 μ wide, and usually upward of 200 μ high.

At this stage successive proliferation of asci begins, first by the appearance of a single oval bud from the center of the apex. This bud enlarges and produces other buds in succession. Each cell that arises in this manner is capable of supporting a whorl of asci, and consequently a branched chain of cells is formed from the original bud (FIGS. 9, 10). Since the apex continues to proliferate cells, each of which produce successive proliferations, a complex head of asci soon forms, measuring up to 50 μ in diameter. The number of asci in each chain varies, but from 4 to 6 orders of cells are common.

The basal cells of the chains are often much enlarged and form a crown of from 4 to 6 cells at the apex of the ascophore. In size, the largest of these range from 8.5–15 $\times$ 2.5–4.5 μ. Some of them remain sterile. The second row of cells, and rarely some of the other cells, may also be somewhat enlarged. It is considered probable that the enlargement seen in these lower cells is dependent on the amount of sugar in the medium, since on a rich medium giving luxuriant growth they are large, and in a poorer medium they are only the size of normal asci. The latter are from 4.4–6.6 by 2.5–3.1 μ.

The formation of ascospores proceeds in basipetal succession from the peripheral asci downward through the chain (FIG. 9). In a mature ascus



FIGS. 8–14.

four cucullate ascospores are visible through the thin, transparent ascus wall. These spores lie closely packed together and are arranged almost invariably in the same way. Two of the spores lie singly at either end of the ascus, with brims facing inward, and the remaining two with brims together and diagonal to the axis, are found in the center of the cell (FIG. 12). The only variation from this arrangement occurs in the larger cells where the spores lie in a straight line. On one occasion eight spores were noted in an ascus, and on another only two.

When the spores are mature, gelatinization of the ascus wall takes place, releasing the spores in a mucous matrix. The released spores adhere to the remaining asci and accumulate there. Thus, the entire head of asci is eventually transformed into a mucous sphere of spores (FIGS. 4, 11). The spores measure 2.5–3.3 × 1.8–2.5 μ.

Sometimes, a new ascophore is proliferated through the apex of the parent ascophore, the younger one being of a smaller size but in every other respect similar to the parent (FIG. 14). With the completion of sporulation in the asci, the ascophore walls lose much of their rigidity and eventually collapse.

GERMINATION

Both the conidia and ascospores germinate within a few hours if planted on a suitable medium. The ascospore first swells until it measures from 4–4.5 × 3–3.5 μ, and then a germ tube emerges through the wall of the spore usually parallel to the flattened side. After it has grown out a short distance, a cross wall appears in the germ tube close to its site of origin. Then a second germ tube commences to grow out usually from the opposite side of the spore. Each germ tube measures from 1.3 to 2.5 μ in diameter, elongates and becomes septate, afterwards forming side branches.

If germination takes place in a liquid medium or submerged in agar, a budding mycelium is produced, the buds of which are broader and rounder than the conidia produced on the aerial conidiophores.

FIG. 8. Three stages in the formation of the ascophore, stained with Cotton Blue in lactophenol, × 375 approx. 9. Head of asci with outer asci showing ascospores in formation, × 930 approx. 10. Mature asci in whorls on elongated sterile cells, × 930 approx. 11. Head of liberated ascospores, × 930 approx. 12. Asci containing four spores in typical internal arrangement, × 930 approx. 13. Ascospores mounted in aqueous Safranin, × 930 approx. 14. Secondary ascophores proliferated through older ones, × 375 approx.

DISCUSSION

Within the last few decades, various authors, including Zender (**1925b**), Gaumann and Dodge (**1928**), Stelling-Dekker (**1931**), Nannfeldt (**1932**), Dodge (**1935**) and Guilliermond (**1940**), have given thought to the possible relationships among simple forms of Ascomycetes, and have arrived at a number of classifications and evolutionary schemes. White (**1942**) stated that, "Attempts at a natural classification, however, still are hampered by a scarcity of connecting forms and by a paucity of detailed knowledge of certain known forms, so that the discovery and assiduous study of additional forms is greatly to be desired."

Ascocybe, with its unusual morphology, is a new member of this general group of organisms. Its position in a natural classification remains a matter of interesting speculation.

Zender (**1925b**), as mentioned earlier, proposed a natural classification on the basis of what he considered to be a character of fundamental importance in indicating relationships—the ascospore type. He was impressed by the fact that a characteristic spore type, such as the one shaped like a bowler hat, was present in genera assigned to several families, and a study of the organisms concerned only added further evidence to his belief that these forms were related. He regarded the cucullate spores and the saturnine spores, which may be either smooth or verrucose, as related types. In the family Endomycetaceae, as he conceived it, there thus appear three genera, *Endomyces, Williopsis* and *Schwanniomyces,* each of which are based on these three spore types. Zender claimed that all three genera were also similar in their biochemical properties.

He contended that, since the genus *Endomyces* was founded on the species *E. decipiens* (Tul.) Rees and this species possessed cucullate ascospores, all the species placed in this genus should also show this spore type. Instead, however, species which were later added to the genus vaguely resembled *E. decipiens,* but possessed spores that were, in many cases, quite different from those of the type species. Zender also asserted that some of the characters which authors have used as a basis for family and generic separations among reduced forms have been of secondary importance. For example, he showed that, in many cases, the absence of true mycelium in the yeast-like forms was a function of the culture medium. Since Zender thus considered the all-important criterion to be the spore shape, he felt justified in including in the genus *Endomyces,* species previously placed in the genera *Hansenula* (*Willia*), *Zygosaccharomyces,* and *Hanseniaspora,* in addition to species of *Endo-*

myces which have the cucullate spore. The genus is thus composed of a series of organisms ranging from those in which typical, well-developed mycelium is formed to those in which it is absent.

Besides having this peculiar spore in common, members of the Endomycetaceae also produce budding-type conidia, or oidia, and have a fruity odour. This odour was shown by Zender to be due to the production of an ester rather than an alcohol, as in most of the Saccharomycetaceae. This is considered to be additional evidence that yeast-like forms that produce cucullate ascospores, such as *Hansenula anomala* (Hansen) Sydow, are not true yeasts and should not be placed in the Saccharomycetaceae. It is obvious from these considerations that *Ascocybe* will fall in quite naturally with this series of forms, since it has in common with them a fruity odour and conidia of this type.

In his description of the Endomycetaceae, Zender states that reproduction is by means of asci which are produced terminally on the mycelium, in the intercalary cells, or in the isolated non-budding or budding cells, with one to four spores per ascus. The specialized ascophore found in *Ascocybe* is therefore considered of sufficient importance to require the erection of a new genus within the family. Its presence in the family does not raise any difficulties, however, as it is seen to find a very natural place within the series. In *Hansenula anomala* (Hansen) Sydow (Dodge, **1935**) which is a yeast-like form with only a trace of mycelium, the asci are produced in separate cells. In *Endomyces fibuliger* Lindner (Gäumann and Dodge, **1928**), any cell of the mycelium can apparently become an ascus. In *E. lindneri* Saito and *E. hordei* Saito (Gäumann and Dodge, **1928**), the production of asci is limited to terminal cells of the ordinary mycelium, whereas in *Ascocybe* the asci are produced on the terminal cells of a specialized ascophore.

It should be noted, however, that *Ascoidea rubescens* Brefeld, which has in common with the members of the genus *Endomyces* the cucullate ascospores and budding-type conidia, was separated from the Endomycetaceae in Zender's classification and put into a new family. It is questioned, as indeed Zender did himself, whether this separation is justified simply on the basis of the multispored ascus.

A study of the literature permits certain comparisons between *Ascocybe* and other fungi producing cucullate spores. Two very interesting forms described by Webb (**1945**) as sporogenous yeasts and called *Endomycopsis* spp. Forms A and B, show a resemblance to *Ascocybe* in their manner of producing asci in chains and whorls. They were both isolated from beetle tunnels in Australian timbers. From the author's account, Form A produces on malt agar a tough, much wrinkled buff-

colored colony with distinctly mycelial edges. The asci are produced in whorls at the end of much branched hyphae, and contain four large, cucullate ascospores, which range in size from 8–14 × 4–6 μ. After the ascospores have been shed, a new ascus is sometimes seen to grow up inside the old one. The colony of Form B on malt agar is white and shining, somewhat wrinkled and fluted in the center but smooth towards the outside with mycelial edges. The asci in Form B arise in chains as well as whorls on the branched, septate mycelium and contain four small, cucullate ascospores, which range in size from 3–5 × 1.5–3 μ. Unfortunately, the cultures of these fungi could not be examined as they had been discarded. It is very possible that they are closely related to *Ascocybe*.

The production of asci in chains is also known in the species *Endomyces chodati* Zender, isolated from banana. Zender (**1925b**) states that, "Dans l'*Endomyces chodati* cette production d'asques dans les bourgeons successifs et terminaux du mycélium n'est pas chose rare. La production des asques n'est pas accompagnée ici de la libération successive des spores, mais a lieu en même temps."

The arrangement of ascospores within the ascus also shows some similarity in different species. In the illustration of *Willia anomala* Hansen (= *Hansenula anomala* (Hansen) Sydow) in Wolf and Wolf (**1947**, Fig. 48, D), and of *Endomycopsis lindneri* in Dodge (**1935**, Fig. 21, 5), the spores in the oval asci are observed to take up practically the same relative position to one another as in the asci of *Ascocybe grovesii*. This configuration is considered to be further evidence in indicating relationships among forms which produce this spore type.

Stelling-Dekker (**1931**) created the genus *Endomycopsis*, already mentioned in connection with Webb's two species, and placed in it species which had formerly belonged to the genus *Endomyces*. The genus *Endomycopsis* is characterized by producing septate mycelium with cells showing many-sided budding, and occasionally oidia. The genus *Endomyces*, on the other hand, lacks cells which show many-sided budding, and produces only oidial cells, at the ends of the mycelial branches. Apparently, Stelling-Dekker attaches no taxonomic importance to the character of the ascospore in either of these genera, which may include a number of types. The type species of *Endomyces*, *E. decipiens* (Schröter, **1897**) produces only oidia in its asexual reproduction. *E. fibuliger* (Gäumann and Dodge, **1928**) produces both oidia and budding-type conidia, whereas *E. chodati* (Zender, **1925a**), a yeast-like form, produces only budding-type cells. The ascospore in each of these three species is, however, cucullate.

Zikes (**1924**) questioned the validity of the separation between *Saccharomyces* and *Schizosaccharomyces* simply on the basis of whether the cells are formed as the result of a budding process or of fission. It was his opinion after a study of the organisms, that both methods of reproduction were essentially the same in these two genera. In the budding yeasts (*Saccharomyces*), he found that a new cell grew out from a narrow isthmus, enlarged, and was then cut off by a septum. In the fission yeasts (*Schizosaccharomyces*), a septum divided a cell into two parts, which usually separated afterwards. Zikes found that from one end of the newly-formed cell a new part grew out, the original part of the cell remaining unchanged. This apical type of growth he maintained to be similar to that found in the budding yeasts, and unlike that found in the bacteria where the whole of the young cell enlarged before fission took place. His conclusion was that fission cells in the *Schizosaccharomyces* were merely budding cells which have grown out from a larger base than ordinarily occurred in the yeast cells.

It follows from the above, as already pointed out by Zender, that the oidia and the budding type cells that are found in *Endomyces* spp. are homologous structures. This is not surprising as they are both a means of asexual reproduction in the genus *Endomyces*. A consideration of the type of conidial formation found in *Ascocybe* might even be seen to bear out Zikes' hypothesis that the budding cells and fission cells are not distinct forms. As seen in FIG. 6, the conidia, which have arisen by budding, are very similar to oidia in appearance and manner of septation, and, in effect, are easily detached and break up into separate cells at the slightest disturbance. Zikes demonstrated that the fission yeasts reproduce by apical growth from a large base, and this type of growth is evident in the cells which arise to form the axis of the conidiophore. At a later stage, these cells form polar buds, from somewhat narrower bases than in the axis cells.

Hence the explanation that the oidia encountered in *Endomyces decipiens* are budding cells which have the ability to reproduce only single cells to form a simple filament seems very plausible. They are thus comparable to the early stage of the axis cells in the conidiophore of *Ascocybe*. Apparently, the asexual reproductive cells found in *E. decipiens* have either lost the ability to bud in polar fashion as the cells in *Ascocybe* are capable of doing, or else have not advanced to this stage of [conidial] development. A further example of oidia that bud may be found in the species *E. fibuliger*, in which under favourable conditions the oidia develop into a sprout mycelium. It is thus considered that because oidia and sprouting cells are not inherently different, separations

such as have been made between *Saccharomyces* and *Schizosaccharomyces,* and between *Endomyces* and *Endomycopsis* are not valid.

Such perithecial forms as *Endoconidiophora fimbriata* (Ell. & Hals.) Elliot, *E. moniliformis* (Hedgc.) Davidson and *Ophiostoma leptographioides* Davidson also possess the hat-shaped ascospore. It is conceivable that, if the spore type is a character of fundamental importance in indicating relationships, all of the forms possessing a hat-shaped spore may eventually be brought together into one family. However, it is quite possible that this spore type might arise more than once in the course of evolution, and in the absence of other correlated morphological and biochemical similarities, there would not seem to be any justification for bringing these forms together at the present time.

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SPECIES OF COLLETOTRICHUM FROM LEGUMES [1]

L. H. Tiffany and Joseph C. Gilman

(with 25 figures)

In the course of an investigation of the soybean anthracnose (Tiffany, **28**), the establishment of the identity of the causal fungus with the *Colletotrichum* from lima bean (*Colletotrichum truncatum* (Schw.) Andrus & Moore) led to the collection of the species of *Colletotrichum* on that and other leguminous hosts for study of their relationships. Comparisons were made of the members of this collection with reference to their host ranges, cultural characters and spore morphology. The results of this study are reported here.

MATERIALS

Cultures were received from Dr. F. R. Jones of the laboratory of the Division of Forage Crops and Diseases at Madison, Wisconsin; Miss Helen S. Sherwin of the Division of Forage Crops and Diseases at Beltsville, Maryland; Dr. J. G. Atkins of the Louisiana Agricultural Experiment Station, Baton Rouge, La.; Dr. J. C. Walker of the Department of Plant Pathology, University of Wisconsin; Dr. J. L. Weimer of the Division of Forage Crops and Diseases of Experiment, Georgia; Dr. M. A. Smith of the Division of Marketing, United States Department of Agriculture, Chicago, Illinois; Dr. D. E. Ellis, North Carolina Agricultural Experiment Station, Raleigh; Dr. P. H. Leyendecker, New Mexico Agricultural Experiment Station, State College, New Mexico; Dr. G. C. Kent, New York (Cornell) Agricultural Experiment Station, Ithaca; Dr. J. M. Crall, Iowa Agricultural Experiment Station, Ames; and Dr. J. W. Gerdeman, University of Illinois, Urbana. A slide of *C. viciae* was received from Dr. C. L. Fergus, Pennsylvania State College. The sources of all cultures are indicated under the discussion of each species.

All of the isolates examined were maintained on comparable media and the various characteristics discussed have been constant during the

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time these forms have been in culture. They have been studied on various natural and synthetic media, but growth and spore production on the latter did not differ appreciably from that on potato dextrose agar. Whenever possible, conidia have been used as the source of inoculum for transfers. Spores for inoculations were obtained from cultures on sterilized soybean stems, and the conidial measurements presented were made of spores produced on this medium.

Cross inoculations on the ranges of host plants presented in the discussions under each species were made in the greenhouse. A conidial suspension was atomized on the plants. The plants were placed in a moist chamber for thirty-six hours, after which they were removed and maintained under greenhouse conditions. Plants in various stages of growth were used, and reisolations were made from the inoculated plants.

Upon examination, the species fell into two clearly defined groups: (1) those having straight spores and (2) those with curved spores. The ascus stages that have been found are all confined to the straight-spored group, although *Glomerella glycines* Lehman & Wolf, when first described, was thought to be the ascus-stage of *Colletotrichum truncatum* of the curved-spored group.

CURVED-SPORED GROUP

COLLETOTRICHUM TRUNCATUM (Schw.) Andrus and Moore, 1934. Phytopath. **25**: 121.

Vermicularia truncata Schw. 1832. Syn. Amer. Bor. No. 1865.
Vermicularia polytricha Cke. 1883–84. Grevillea **12**: 24.
Colletotrichum caulivorum Heald and Wolf. 1911. Mycologia **3**: 10.
Colletotrichum glycines Hori. 1919. Jour. Col. Agr., Hokkaido Imp. Univ. **9**: 159.
Colletotrichum viciae Dearn. & Overh. 1928. Mycologia **20**: 235.

Acervuli linear to oval, black, adnate, crowded, hemispheric to truncate-conical, erumpent; setae numerous, filiform, divergent, variable, long and short intermixed, 60–300 × 3.5–8 μ, may be lacking or surrounding sclerotia; conidia falcate-lanceolate, hyaline, 17–31.5 × 3–4.5 μ.

On stems and pods of *Phaseolus lunatus* L., *P. vulgaris* L., *Medicago sativa* L., *Melilotus alba* Desr., *Trifolium pratense* L., *Glycine max* (L.) Merr., *Vicia villosa* Roth., and *Lotus purshianus* Clem. & Clem. (*L. americanus* (Nutt.) Bisch.).

Schweinitz originally described *Vermicularia truncata* from the stem of *Phaseolus* sp. in Pennsylvania. The same fungus was described by Cooke as *Vermicularia polytricha* on lima beans from South Carolina,

and Heald and Wolf, in 1911, described it again from the stems of common garden bean in Texas as *Colletotrichum caulivorum*. Following the work of Andrus and Moore, *C. truncatum* has become the accepted name for this fungus.

The fungus was first recorded from soybeans by Hemmi in a paper reporting its isolation from anthracnose-diseased soybeans by Takimota in September, 1917. Its important morphological features, together with drawings, were presented and it was named *Colletotrichum glycines*, the name being ascribed to Hori. The same fungus was found later in North Carolina on soybean by Wolf and Lehman (**34**). They also found an ascogenous fungus, a *Glomerella*, on overwintered diseased soybean stems that produced perithecia in culture. (See page 68.)

Colletotrichum truncatum has been reported (Cox, **9**) to attack the stems, pods, leaves and blossoms of lima beans; and the pods and stems of soybeans (Lehman and Wolf, **20**). On lima bean pods, invasion results in small reddish blotches that spread indefinitely without the formation of a definite lesion. In severe cases, the branches may be girdled and killed. On soybean, sporulation is limited to the stems and pods; the organism being capable of attacking the plant at any stage of growth. It has been reported to cause the premature death of plants in the field and to inhibit seed formation if early infection had occurred. Ling (**21**) found the organism to be an important factor in seedling-killing, either before or soon after emergence.

Cox (**8**) made successful inoculations with *C. truncatum* from lima bean on eleven genera of legumes. Walker (**29**) says of *C. pisi:* "There are indications that it is synonymous with *C. truncatum*, the incitant of stem anthracnose of bean and lima bean."

An isolate of *C. truncatum* from lima bean was obtained from Dr. D. E. Ellis from North Carolina. Numerous isolates from various varieties of soybeans were obtained from diseased material in Iowa. All of these isolates were identical in cultural characteristics. Very sparse mycelial growth was produced on either artificial media or on sterilized soybean stems. Densely setose acervuli covered with pink to cream-colored masses of conidia were formed abundantly on either type of substrate. Size of acervuli and the length, color and septation of the setae varied with the age of the culture. Vegetative mycelium became olive green to black with little aerial mycelium produced. The conidia are hyaline, curved, 21–30 × 3.5–4 μ (FIGS. 1, 2).

Two cultures of *C. truncatum, 2522* and *2523*, from *Lotus purshianus* (*L. americanus*) at San Antonio, Texas, and one, *2524*, from alfalfa, at Raleigh, N. C., were obtained from Miss Helen Sherwin. *2522* and

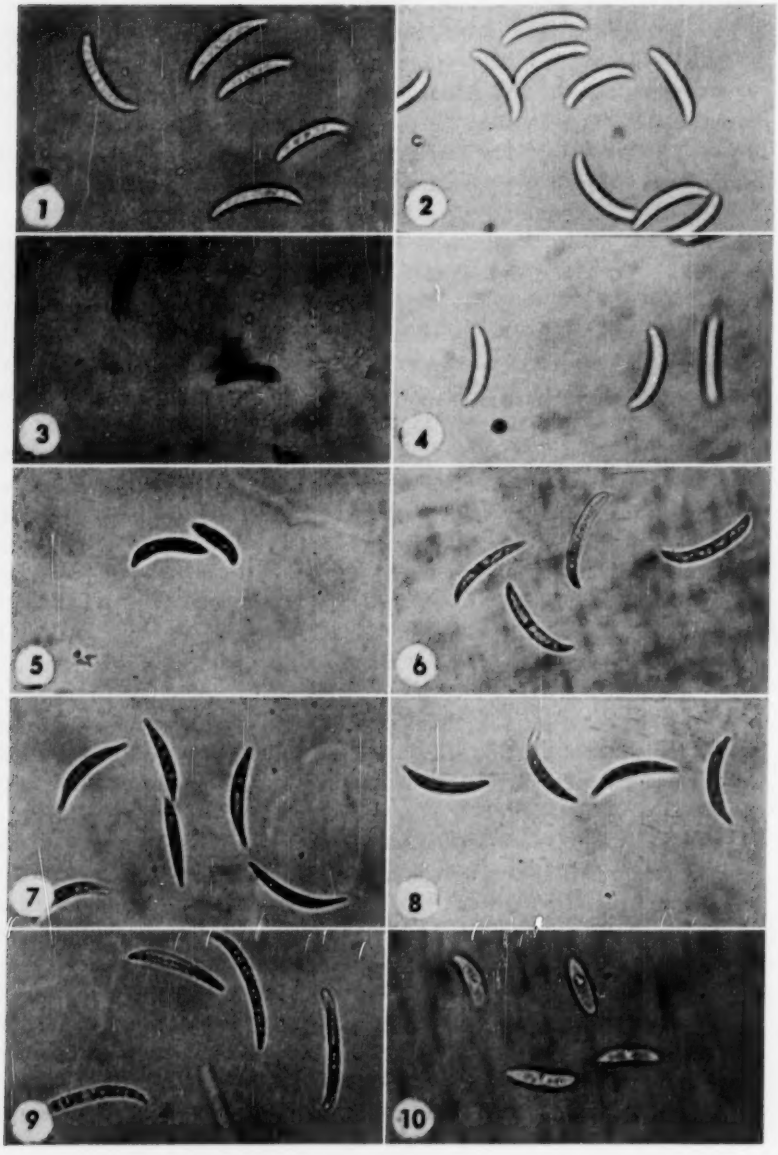
2524 were similar in growth on potato dextrose agar, forming dark subsurface mycelium with very little aerial growth. Conidia and setae were produced sparsely over the colony surface. *2523* produced very dark subsurface mycelium, little aerial mycelium, and well-organized acervuli scattered over the surface of the colony. Spores were produced in profusion in the acervuli, being visible in cream-colored masses. All of the cultures were similar in appearance on sterilized soybean stems, all producing setose acervuli with pink to cream masses of conidia. The size ranges of the conidia produced by the isolates were: culture *2522*, 17–21 × 3.5–4.5 μ (FIG. 4); culture *2523*, 17.5–26 × 3.5–4.5 μ; *culture 2524*, 21–31.5 × 4.5 μ.

Two cultures of *C. truncatum* were received from Dr. J. M. Crall. Culture *102* was isolated from a red clover seedling, culture *106* from a red clover plant that showed head and petiole blight. Both cultures were similar in appearance on potato dextrose agar, forming a subsurface growth of dark mycelium with scattered sclerotia. A few organized acervuli with cream-colored spore masses were produced on the surfaces of the colonies. As they became older, a gray aerial mycelium overgrew the acervuli. On sterilized soybean stems growth was identical with that of the other isolates discussed; numerous acervuli were produced over the entire surface. Spores of culture *102* ranged in size 19.3–24.5 × 3.5–4.5 μ; of *106*, 24.5–28 × 3.5–4.5 μ.

Material for examination of *C. viciae* from the type specimen (FIG. 3) was made available by Dr. Fergus. It compared with *C. truncatum* in all respects except for slightly smaller conidia quite comparable to the conidia of isolate *2522* from *Lotus*. This difference was not considered sufficiently great to warrant the consideration of *C. viciae* as a separate species.

In India, studies have been made by various workers of some of the species of *Colletotrichum* which produce falcate conidia (Dastur, **10**; Ling and Lin, **22**; Ramakrishnan, **25**). Among those included have been *C. capsici* which caused ripe fruit rots of pepper, eggplant, and tomato, *C. indicum* from cotton, *C. truncatum* from lima beans, and *"Glomerella glycines"* (*Colletotrichum truncatum* (not *Glomerella glycines*, see page 68)) from soybeans. *Colletotrichum indicum* and *"Glomerella glycines"* have been noted to be alike in that they both attack their natural host plants in the seedling stage. As isolates of only *Colletotrichum truncatum* from lima bean and soybean have been observed, no further comment concerning this group can be made.

Successful cross inoculation with cultures of *C. truncatum* were completed on soybean, alfalfa, sweet clover, lima bean, and pea with lima



FIGS. 1–10.

bean isolate. Inoculations with the soybean isolates were successful on soybean, alfalfa, sweet clover, red clover, lespedeza vetch, ladino, birdsfoot trefoil, lima bean and pea. The isolates from soybean were slightly more pathogenic on soybean than on lima bean; conversely, the lima bean isolate was a more successful parasite on its original host than it was on soybean. These results are in agreement with those reported by Holdeman (**14**) in cross inoculations with similar isolates from these two hosts. The soybean isolate was reisolated from green plants of birdsfoot trefoil, sweet clover, ladino, alfalfa, and soybean, none of which showed any symptoms of disease.

COLLETOTRICHUM VILLOSUM Weimer, 1945. Phytopath. **35**: 977.

Acervuli amphigenous, more commonly hypophyllous, 25–100 μ in diameter, larger and irregular when confluent, gray to warm buff to ochraceous buff from conidial masses; setae lacking or abundant, usually red-brown, paler toward apex, 45–150 × 6.3–9.5 (av. 85 × 7.5) μ, tapering to a rounded point, 1–4-septate; conidia hyaline, slightly curved, bluntly tapered at both ends, 1-celled, 15–24 × 3.5–4.5 (av. 18.9 × 4) μ.

Parasitic on leaves and stems of *Vicia* spp., forming more or less circular to linear spots, the light brown to warm sepia border becoming dark brown to black on stems.

The only culture of this species examined was isolated from vetch in Georgia by Dr. J. L. Weimer. The colonies were quite different in general appearance from those of any of the other *Colletotrichum* isolates examined. On potato dextrose agar, they grew very slowly, assuming a deeply convoluted form. Spore production occurred only on cultures that were approximately three weeks old, but well defined acervuli were not produced. On sterilized stems, small acervuli with scattered setae were formed, accompanied by masses of vegetative mycelium that were organized in dark heaped colonies of much the same type as were formed on agar. The setae were dark, usually with several septa. The conidia were hyaline, unicellular, curved, with rounded ends, and 16–21 × 3.5–4.5 μ (FIG. 10).

Successful cross inoculations were obtained only on vetch.

The restricted growth on both potato dextrose agar and on sterilized stem simulated the colonies of certain members of the Myriangiales and

FIGS. 1–10. Conidia from the curved-spored species of *Colletotrichum* from legumes (× 450). 1–4. *C. truncatum*. 1. From lima bean; 2. From soybean; 3. From vetch (stained); 4. From *Lotus*. 5–9. *C. graminicolum*. 5. From oats; 6. From alfalfa; 7. From sweet clover; 8. From alfalfa; 9. From Ladino clover. 10. *C. villosum* from vetch.

suggested that this isolate might have affinities with the genus *Sphaceloma* in spite of the presence of setae that were not characteristic of that genus. Hence cultures were submitted to Miss A. E. Jenkins for examination. Miss Jenkins after studying this isolate and culturing it stated in a letter: "The cultural growth does not conform to the Myriangiales as they are known at present."

COLLETOTRICHUM GRAMINICOLUM (Cesati) G. W. Wilson, 1914. Phytopath. **4**: 106.

Dicladium graminicolum Cesati. 1852. Raben., Herb. Viv. Myc. *1677*. Flora **35**: 398.

Psilonia apolospora Berk. & Curt. 1855. Ravenel, Fungi Carol. Exs. **3**: 83.

Vermicularia culmigena Cooke. 1881. Ravenel, Fungi Amer. Exs. *531*. Not *V. culmigena* Desmaz., Ann. Sci. Nat. III, **3**: 363. 1845.

Steirochaete graminicola Sacc. 1886. Syll. Fung. **4**: 316.

Vermicularia sanguinea Ellis & Halst. 1888. Jour. Myc. **4**: 8.

Colletotrichum lineola pachyspora Ellis & Keller. 1889. Ellis & Ev. North Am. Fungi *2181*.

Colletotrichum bromi Jennings. 1890. Texas Agr. Exp. Sta. Bul. **9**: 25.

Vermicularia lolii Roum. 1891. Rev. Myc. **13**: 131.

Colletotrichum sanguineum Ell. & Hals. 1896. Ellis & Ev. North Am. Fungi *3466*.

Vermicularia holci Sydow. 1899. Hedwigia (Beibl.) **38**: 137.

Colletotrichum cereale Manns. 1909. Ohio Agr. Exp. Sta. Bul. 203.

Acervuli superficial, circular to oval, with dark mycelium forming the basal stroma; setae black to dark brown, forming through or surrounding the conidial-forming stroma of the mycelium, variable, septate and tapering at the apex; conidia falcate, slightly curved, hyaline, 1-celled, 18–31 × 3.5–4 μ.

On various Gramineae, *Melilotus alba* Desr., *Medicago sativa* L., and *Trifolium repens* L.

The original description of an anthracnose fungus of grasses was that of *Dicladium graminicolum* Cesati from stems of *Echinochloa crusgalli* and *Zea mays* in Italy in 1852. The measurements of the setae and conidia of this fungus are the same as those of some twelve other species that have been named since as causal agents of anthracnose of various grass hosts, principally in the genera *Vermicularia* and *Colletotrichum*. The conidia of these twelve include curved spore types with round and

pointed ends. Selby and Manns' illustrations of their *Colletotrichum cereale* indicated a curved spore type with rounded ends, but other species descriptions indicated conidia with pointed ends. Wilson examined material of all species on grasses that had been described at that time and suggested the name of *C. graminicolum* for the entire group. More recently, *C. graminicolum* has also been reported to occur on alfalfa. Jones and Weimer (**18**) included it as a member of the group of anthracnose organisms present in an alfalfa nursery in Griffin, Georgia.

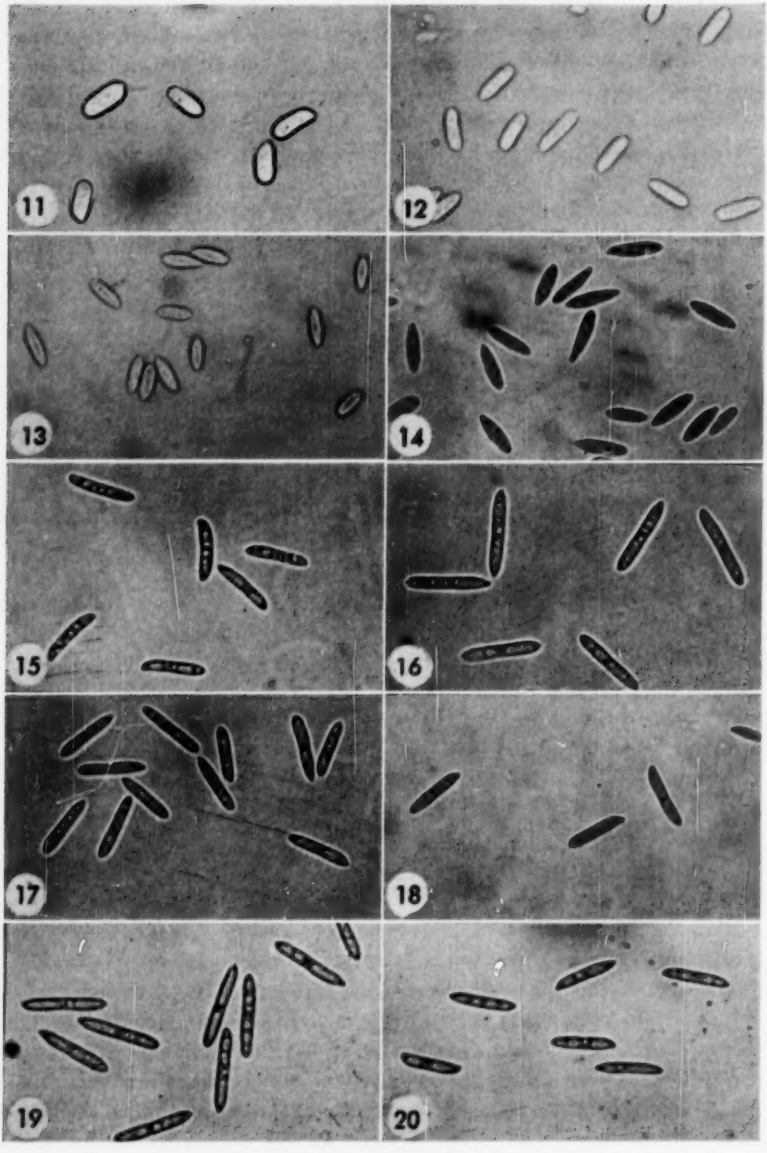
Among the cultures obtained from Dr. F. R. Jones were isolates *1747* and *J2*, from alfalfa, that had been isolated at Madison, Wisconsin and tentatively identified as *C. graminicolum*. For purposes of comparison, a *C. graminicolum* isolate was obtained from oat plants at Ames.

The two groups of cultures were quite different in gross cultural characteristics. Isolates *1747* and *J2* were distinguished on both potato dextrose agar and sterilized soybean stems by the sparse development of vegetative mycelium and the abundant production of setose acervuli with their cream-colored masses of spores. The individual spores were hyaline, curved (often markedly so), unicellular, with rounded ends, and ranged in size from 31.5–21 × 2–2.5 μ (FIG. 6). The oat isolate produced a predominantly mycelial type of growth on potato dextrose agar. Scattered abnormal spores were produced (FIG. 5), but no organized acervuli were formed. When the isolate was cultured on sterilized soybean stems, numerous setose acervuli identical with those of the alfalfa isolates were present. The acervuli were soon obscured by a mass of gray vegetative mycelium. Less difficulty with the mycelial overgrowth occurred when only spores were used as the transfer inoculum.

Greenhouse inoculations of *1747* were successful on alfalfa, sweet clover, red clover, birdsfoot trefoil, ladino, and vetch. No attempts were made to check the pathogenicity of the isolates on oats or on possible grass hosts. Inoculations of soybean and lespedeza were unsuccessful.

Plants infected by the alfalfa isolates of *C. graminicolum* did not differ greatly in appearance from those successfully inoculated with *C. destructivum*. Young alfalfa plants were killed and their stems covered with acervuli in two to three days. Definite stem lesions were formed on older plants. The fungus progressed more slowly in the other hosts upon which it was successful inoculated. Petioles of young red clover leaves were girdled and acervuli produced in abundance on the dead leaflets.

Two other cultures of *C. graminicolum* have been examined. One was from ladino clover, one from alfalfa. They were received from Dr. P. J.



FIGS. 11–20.

Leyendecker, and had been isolated from diseased material near State College, New Mexico, in October, 1951. Both isolates were indistinguishable in cultural characteristics from *1747* and *J2*, and the curved, hyaline conidia with rounded ends ranged in length from 25 to 31.5 μ (FIG. 9). No cross inoculations have been attempted with these isolates.

Two curved-spore isolates, *74* from alfalfa and *22* from sweet clover, were not identical with the four isolates just discussed. They were indistinguishable, however, from other entities that have been considered to be *C. graminicolum*. Both were isolated from Iowa material and were identical in all characteristics; both formed a sparse mycelial growth interspersed with numerous dark sclerotia on potato agar and both developed acervuli and sclerotia on sterilized soybean stems. The acervuli possessed scattered setae that were almost buried in the pink to cream-colored spore masses, and did not differ appreciably from those of *1747* and *J2*. Individual conidia were hyaline and ranged in length from 21 to 28 μ. They differ from typical *C. graminicolum* conidia in their pointed ends (FIGS. 7, 8). Inoculations with *74* and *22* were successful on red clover, sweet clover and alfalfa.

All the cultures discussed in this section are tentatively referred to *C. graminicolum*. At present, a number of quite different curved-spore forms are included in this species, but until observations can be made of a larger number of anthracnose organisms from various grass hosts, the significance of these differences cannot be accurately evaluated.

STRAIGHT-SPORED GROUP

COLLETOTRICHUM TRIFOLII Bain & Essary, 1906. Jour. Myc. **12**: 192.

Acervuli erumpent, scattered or gregarious; conidiophores hyaline, cylindrical or fusoid; setae among the conidiophores, 1- or 2-celled, few or numerous, dark, paler toward the apex, 39–62 × 4–7 μ, often curved or nodulate; conidia hyaline, straight with rounded ends, 11–13 × 3–4 μ, 1-celled.

In brown to black, often depressed, spots on living stems and petioles of *Trifolium pratense* L. and *Medicago sativa* L.

Bain and Essary (**2**) described *Colletotrichum trifolii* as the causal agent of anthracnose of red clover in Tennessee and recorded its occur-

FIGS. 11–20. Conidia from the straight-spored species of *Colletotrichum* and *Glomerella* from legumes (× 450). 11. *C. trifolii* from red clover. 12. *C. lindemuthianum* from garden bean. 13–14. Conidia of *Glomerella cingulata*. 13. From kudzu; 14. From apple. 15–20. Conidia of *Glomerella glycines*. 15. From red clover; 16. From soybean; 17. From alfalfa; 18. From vetch; 19. From garden pea; 20. From pure culture.

rence as a severe pathogen on seedlings of both alfalfa and red clover. Later, on mature plants, this species was found to cause stem lesions which were distinguishable from the symptoms due to *Kabatiella caulivora* (Kirchn.) Karak. only by the presence of the typical acervuli and black setae of the *Colletotrichum*. Both of these fungi are present in Iowa; spring temperatures are the decisive factor as to which will be more prevalent in any given season.

A detailed discussion of symptoms and the effect of environmental conditions for the development of southern anthracnose is presented in Montieth's bulletin (**24**). In both the disease caused by *Colletotrichum trifolii* and northern anthracnose caused by *Kabatiella caulivora*, lesions that spread rapidly both radially and longitudinally to girdle the plant part invaded are a prominent symptom. Withered leaves and dark sunken stem lesions are characteristic of the disease on plants which have not been completely killed. *Colletotrichum trifolii* was described by Henderson and Smith (**13**) as the causal agent involved in a stem and root rot of alfalfa in which no conspicuous lesions were formed.

An isolate of *C. trifolii* from red clover from Iowa, isolates *357* and *371* from alfalfa obtained from Dr. F. R. Jones at Madison, Wisconsin, and isolates *3017* and *3020* from alfalfa at Beltsville, Md., obtained from Miss Helen Sherwin, were examined. The cultures formed a sparse olive green vegetative mycelial growth on potato dextrose agar, sometimes accompanied by the scattered production of setae and conidia, but on sterilized soybean stems numerous small setose acervuli were formed. Although the cultures of *C. trifolii* examined were similar in gross cultural aspect and formed no sclerotia, sclerotial cultures such as occur in many other species of *Colletotrichum* have been reported by Hopkins (**15**). The conidia were straight, hyaline, rounded at the apex and bluntly pointed at the base, 10.5–12.9 × 3.5–4 μ (FIG. 11).

C. trifolii was successfully established on red clover, alfalfa, and sweet clover. The lesions produced on these hosts were indistinguishable from those caused by *C. destructivum*. The most common disease symptom on young plants was the occurrence of numerous dried and curled leaves which resulted when the fungus girdled the petiole.

COLLETOTRICHUM DESTRUCTIVUM O'Gara, 1915. Mycologia **7**: 37.
Colletotrichum sativum Horn. 1952. Phytopath. **42**: 670–674.

Acervuli small, 25–70 μ in diameter, scattered or gregarious, erumpent, raised; conidiophores fasciculate, hyaline, cylindrical or fusoid; setae between (among) the conidia, few or numerous, fuliginous or black-brown, straight or curved or flexuous, often nodulose, continuous or

septate, subacute or rounded, often tapering, 4.5–7 μ thick at base, 38–205 μ long; conidia hyaline, granulose, 1–4-guttulate, straight or slightly curved, ends somewhat rounded 14–22 × 3–4.5 μ.

On petioles and stems of living or dying *Trifolium pratense* L., *Medicago sativa* L., *Glycine max* (L.) Merrill, *Vicia* spp., and *Melilotus alba* Desr. forming indeterminate brown spots.[2]

Colletotrichum destructivum, which was described by O'Gara from the Salt Lake Valley, Utah, produced disease symptoms similar to those attributable to *C. trifolii;* however, the conidia of the former were consistently larger than those of the first described pathogen. *C. destructivum* was reported by Weimer (**30**) to be the pathogen responsible for dark brown leaf spot of alfalfa in Georgia. Bain (**1**) reported a leaf spot of soybean associated with a straight-spored *Colletotrichum*, but gave no details concerning the causal organism.

A number of isolates of this species have been obtained from red clover, alfalfa, and soybean from various fields in the vicinity of Ames. Three cultures from Dr. F. R. Jones, isolates *335* and *351* from alfalfa in Wisconsin and *402* from alfalfa at Lincoln, Nebraska; two cultures from Dr. J. M. Crall, isolate *118* from red clover stems at Marshalltown, Iowa, and isolate *64* from alfalfa plants with stem blight in Johnson County, Iowa; four cultures from Miss Helen Sherwin, isolate *2800* from alfalfa at Leland, Miss., *2939* from Kenland red clover at Stratford, Va., *3432* from Turkestan alfalfa at Columbus, Ohio; two cultures from Dr. J. G. Atkins, *192* and *192Y*, both from vetch in Louisiana; one culture from Dr. J. W. Gerdeman, *IC4*, from sweet clover in Illinois; and an isolate from pea that had been carried as *C. pisi* obtained from Dr. J. C. Walker were also included.

Two major growth types on potato dextrose agar were represented in this collection of cultures. One type, typical of the soybean and pea isolates, was characterized by the formation of a mat of white subsurface mycelium that was irregularly dotted with numerous black sclerotial bodies at the surface of the agar. The sclerotia were masses of large, heavily pigmented cells that were packed with oil globules. On sterilized soybean stems acervuli were formed as well as sclerotia, some of them originating from a layer of basal cells much like those that formed the

[2] Since the submission of the manuscript, *Colletotrichum destructivum* was collected from *Bromus inermis* Leyss. that was growing in a mixed stand of brome and alfalfa. Cross-inoculations of the brome isolate were successful on *Trifolium pratense, Melilotus alba* and *Medicago sativa.* [Tiffany, L. H. Phytopath. **43**: 486–487. 1953.]

sclerotia. Some of the sclerotia had a tuft of setae on the top and occasionally a few conidiophores as well.

The other growth type, which was typical of all the other isolates, varied with the temperature at which the cultures were grown. When they were maintained at temperatures between 20° and 30° C, no organized acervuli and very little aerial mycelium were produced. Abundant individual scattered setae were formed over the entire surface of the colony, and were soon buried in the masses of conidia that were produced in such profusion that the cultures had a pink- to cream-tinted, slimy appearance. Below 15° C, growth was primarily vegetative with only scattered production of conidia. Irrespective of temperature, the vegetative mycelium itself was olive green to black and composed of large irregular cells. The mycelium of the colonies formed at the higher temperatures was not as highly pigmented as at the lower. When these isolates were cultured on sterilized soybean stems, all of them produced abundant setose acervuli and conidia that were light pink to cream-colored in gross appearance.

The conidia produced by all of the isolates were hyaline, unicellular, rounded on the apex but bluntly pointed at the base, 14–21 × 3–3.5 μ (FIGS. 15, 16, 17, 20). The setae were black, usually lighter at the apex, and ranged from non-septate to those with four septa, depending upon age.

The occurrence of normal variants within the species has been studied by Chilton (**3**) with *C. destructivum* and Zerkel (**36**) with *C. trifolii*. The possibility that *C. trifolii* and *C. destructivum* are not distinct entities has also been considered. A variety of cultural types could be isolated readily after cultures of either species had been maintained on artificial media for several transfers. Wollenweber and Hopchapfel (**35**) considered all the forms that they found on *Trifolium, Medicago, Serradella, Ornithopus sativus,* and *Trigonella coerulea* to be *Colletotrichum trifolii,* but made no mention of *C. destructivum.*

In all of the isolates examined here however, the isolates of *C. trifolii* have been distinct from the *C. destructivum* forms by virtue of their shorter, somewhat narrower conidia.

The effect of temperature upon the rate of growth, as measured by the daily mycelial increment when the fungi were cultivated on plates of potato agar, was evaluated with numerous isolates of *C. destructivum* from red clover, soybean, sweet clover, and alfalfa, the soybean isolate of *C. destructivum* and *Glomerella glycines.* In all of these, the optimum temperature for mycelial growth lies between 25 and 30° C. The effect of temperature upon germination of the spores of these same isolates was

studied in sterile distilled water. In all species there was little germination below 10° C, or above 30° C at the end of forty-eight hours. Between ninety-five and a hundred percent germination occurred at the range between 15° to 25° C in twenty-four hours, with germination at 30° C approaching one hundred percent at the end of forty-eight hours.

Some of the isolates which produced only a sclerotial type of growth on artificial media, such as the soybean isolate of *Colletotrichum destructivum* and the isolate from peas, produced exactly the same kind of acervuli and conidia as did the *C. destructivum* isolates from alfalfa and the clovers when they were cultured on sterilized stems. Chilton and his associates (**4**, **5**, **6**) have worked out some of the genetic factors responsible for variation in cultures of the *Glomerella* group. They have demonstrated that such common differences as sclerotial type of growth or the production of conidia were controlled by definite genes, often with an allelomorphic series at various loci which control the development of such structures. It seemed illogical to place any weight upon differences or similarities in the gross appearance of the isolates when they were cultured on an artificial medium as an aid in the designation of species.

Size and structure of acervulus and its setae were easily modified by the substrate and environmental factors. Measurements of these structures varied markedly with the age of the culture, and differences in size, pigmentation and septation of the setae occurred during the growth of a single isolate. The gross appearance of the fruiting structure was more stable when the isolates were cultured on sterilized stems; if they varied, they were variable over the same range. Cultures of *C. destructivum* were found by Chilton (**3**) to be exactly alike with respect both to spore characteristics and gross cultural appearance when they were first isolated from diseased host plants. As the isolates were carried in culture on artificial media, various segregates appeared. These apparently did not play an important part as pathogens in the field, however, or such variants should have been picked up in the course of the hundreds of isolations that have been made from naturally infected field material in the present study.

C. destructivum was apparently quite omnivorous, for successful cross inoculations were completed on soybean, alfalfa, sweet clover, red clover, and lespedeza with the isolates from soybean, alfalfa, sweet clover, red clover and pea. The individual isolates from alfalfa, red clover and sweet clover were as pathogenic upon all of the host species on which they were tested as they were on the host from which they had been originally isolated. On both alfalfa and sweet clover, some of the stems failed to develop lesions or other disease symptoms, but the pathogen

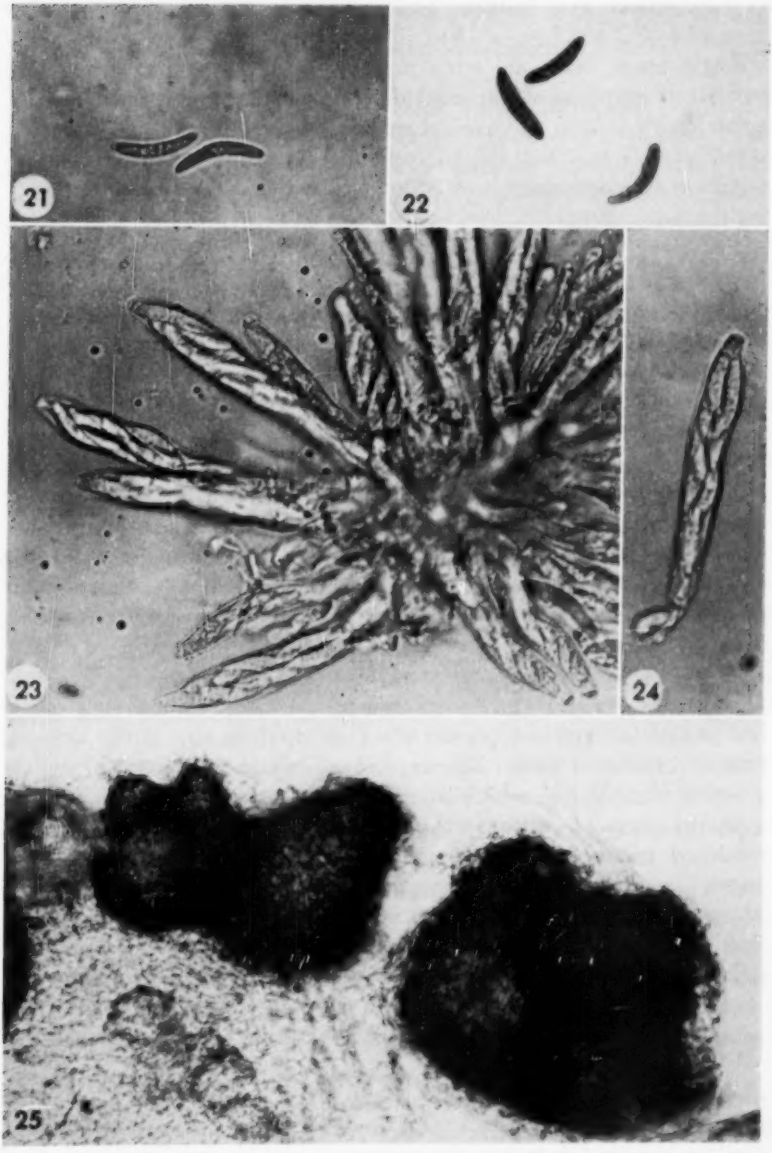
could be readily isolated and the stems assumed a "shepherd's crook" appearance. As the plants became older, symptomless diseased stems and their side branches died without formation of a definite lesion, but acervuli were then produced in profusion over the entire area. This reaction was not obtained when these two hosts were successfully inoculated with other *Colletotrichum* species. *C. truncatum* from soybean, particularly, caused a rapid breakdown of infected tissues when inoculated onto alfalfa, red clover and sweet clover. The sclerotial soybean isolate of *C. destructivum* was not as aggressive a parasite. Even on soybean, it did not seem to be capable of actively parasitizing vigorous, rapidly-growing plants.

Isolates *192* and *192Y* from vetch were received after inoculation studies were completed. However, they agree in morphological and cultural characteristics with the *C. destructivum* group. *192* produced abundant individual scattered setae and conidiophores on potato dextrose agar, while *192Y* was mycelial, producing only occasional scattered spores. On sterilized stems, however, typical *C. destructivum* acervuli and conidia were produced in abundance (FIG. 18).

An isolate labeled "*C.* sp.-vetch" from *Vicia angustifolia* at Baton Rouge, Louisiana, was also received from Dr. Atkins. The conidia were parallel-sided throughout the body of the spore like *Colletotrichum destructivum* but were curved on the ends. Growth on both artificial media and sterilized stems was identical with that of the *C. destructivum* isolates previously discussed. Spore morphology would indicate that it was not among the species that we have studied.

The isolate from peas seemed to be *C. destructivum*. It was not actively parasitic, but was readily isolated from older basal leaves of the plants inoculated, never from the stems. Although this culture was received as *C. pisi*, conidia were of the straight type and the cultural characteristics would indicate that it was not *C. pisi* (FIG. 19). Authentic *C. pisi* material has not been examined.

Some diseased stems of alfalfa and sweet clover plants that had been inoculated with *C. destructivum* in the greenhouse were collected in the fall and placed outside in cheesecloth bags. Samples of these stems were brought into the laboratory at intervals throughout the winter, placed in a moist chamber, and the fruiting structures that developed were examined. In January, perithecia were found on several of the diseased alfalfa stems. They were accompanied by acervuli in which were produced typical *C. destructivum* conidia. The perithecia and ascospores were identical with those of *Glomerella glycines* in all details.



FIGS. 21–25. *Glomerella glycines*. 21. Ascospores from soybean (× 450). 22. Ascospores from alfalfa (× 450). 23. Asci showing bush-like arrangement (× 450). 24. A single ascus (× 450). 25. Perithecia (× 100).

The ascospores were curved, hyaline, unicellular, and ranged in size from 20.4–27.2 × 3.7–4.4 μ (FIG. 22).

Single spore isolations were made from both the ascospores and conidia. Regardless of the original spore source, the forty single spore isolates from conidia and ascospores were of the cultural type discussed as typical of *G. glycines;* also two sclerotial type cultures which produced conidia only when maintained upon sterilized stems were obtained.

GLOMERELLA GLYCINES (Hori) Lehman & Wolf, 1926. Jour. Agr. Res. **33**: 381.

Perithecia membranaceous, rostrate, caespitose, 220–230 μ in diameter, immersed in a stroma. Asci bluntly clavate, with refractive ring in thickened apex, aparaphysate, 70–106 × 9.5–13.5 μ; ascospores hyaline, slightly curved, blunt-pointed, one-celled, 13.2–43.3(18.7–28.1) × 4–6 μ (FIGS. 23, 24, 25).

On decaying stems of *Glycine max* (L.) Merr. and *Medicago sativa* L.

At first Wolf and Lehman (**34**) placed their isolate in *G. cingulata* (St.) Spald. & von S., but later found it to be morphologically different. They therefore considered that their fungus was a distinct entity and described it as *G. glycines*. Liu (**23**) mentioned obtaining an ascogenous stage of *Colletotrichum glycines* that was not *Glomerella glycines*. To date, *G. glycines* has not been reported from the Orient.

A type of isolate different from *Colletotrichum truncatum* was obtained readily from mature soybean stems in Iowa. These isolates did not produce acervuli or conidia when cultured on any of the artificial media which were used. The vegetative mycelium consisted of rapidly growing white hyphae which later became pale to dark orange-pink with scattered areas of sub-surface olive-green mycelium. Perithecia were produced profusely in glomerate masses and were black, membranaceous, rostrate and aparaphysate, and immersed in a stroma (FIG. 25). Mature ascospores, which were present in eight to nine days, were hyaline, curved, rounded at the ends and 20.2–32.1 × 4.4–6.6 μ (FIGS. 21, 23, 24). Similar perithecia could be found on overwintered stems, but no conidial stage has been observed in naturally infected material. This seems to be *Glomerella glycines,* as it agrees well with Lehman and Wolf's description.

When isolates were inoculated onto sterilized soybean stems, small acervuli with brown to black setae were produced in two to three days. Perithecia were forming at the same time, and as they developed much more profusely than did the acervuli, the latter were soon overgrown. The conidia were straight, rounded at the apex and bluntly pointed at

the base, hyaline, unicellular, and 16.3–18 × 3.5–4.5 μ. This conidial stage is not the one that was discussed in connection with *G. glycines* at the time it was described.

Single spore isolates were made from mature ascospores. In some cases, all of the ascospores from one ascus were successfully isolated and cultures established from each. Single ascospore isolations from the spore complements of several asci from the same perithecium were made. In all cases, the ascospore isolates obtained from a given ascus and the isolates from any one perithecium were the same in cultural characteristics. The isolates from one perithecium differed from those of the others in that they did not form the vegetative growth with abundant perithecia described previously as typical of *G. glycines*. Instead, these isolates gave rise to a subsurface mat of dark green vegetative mycelium. These did not react with any of the normal type ascospore cultures to form a line of perithecia when any of the two types were plated together, nor was there any reaction when any two isolates of one group were plated together.

GLOMERELLA CINGULATA (Stoneman) Spald. & von S., 1903. U.S.D.A. Bureau Plant Ind. Bul. 44.

Gloeosporium cingulata Stoneman. 1898. Bot. Gaz. **26**: 69–120.

Perithecia membranaceous, rostrate, caespitose; stromata dark-brown, 125–250 μ in diam.; asci bluntly clavate with refractive ring in thickened apical wall, aparaphysate, 55–70 × 9–10 μ; ascospores hyaline, elliptic, slightly curved, one-celled, 9.4–18.8 × 3.9–5 μ. Acervuli 100–150 μ, black in age; conidiophores simple, hyaline; conidia oblong to elliptic, straight, often tapered slightly at both ends, 10–20 × 4.7 μ (12–16 × 4–5 μ).

On *Lupinus angustifolius* L., *L. albus* L., and *Pueraria thunbergiana* (S. & Z.) Benth. (Kudzu).

Weimer (**31**) reported *Glomerella cingulata* from Georgia on *Lupinus angustifolius* and later with Dunegan (**33**) showed that such infections could originate on peaches or that the fungus could be carried from lupine to peach. Lupine was attacked in the seedling stage under high humidity conditions in all above-ground parts of the plants. Leaves of *L. albus* were also infected and severely injured. The conidia measured 8.4–18.9 × 3.5–6.3 μ with an average of 4.6 × 13.3 μ.

An isolate of *Glomerella cingulata* from kudzu was received from Weimer during the course of the investigation which also corresponded in its spore measurements and cultural characteristics with *G. cingulata* (FIGS. 13, 14). The conidia were elliptic, tapered toward each end, and ranged in size from 8.5–13.6 × 3.5–5.5 μ.

Weimer (**32**) described anthracnose of annual lespedeza as caused by a strain of *Glomerella cingulata*. Disease symptoms were more or less circular, elliptical or angular lesions from 1 to 5 mm in diameter on the leaflets, sometimes resulting in defoliation of the plant, and lesions on stems and petioles that were dark brown to nearly black, circular to linear. In greenhouse inoculation studies comparing the lespedeza isolates with strains of *G. cingulata*, only the fungus from lespedeza gave symptoms. Both conidial and perithecial strains were obtained from diseased plants in the field. The perithecial strains produced ascospores that were slightly curved and measured 13.6–23 × 4.2–6 μ with an average of 19.5 × 4.9 μ. The conidial stage was a *Colletotrichum* with typical 2–4-septate setae with bulbous bases, and conidia ranging from 13–22 × 3–6 μ with an average of 18.2 × 4.1 μ. Weimer separated his fungus from *Colletotrichum destructivum* upon the fact that O'Gara had described *C. destructivum* as having setae which are often nodulose and continuous or obscurely 1-septate.

One of Weimer's cultures from lespedeza has been available for examination during these studies, and has been compared with several strains of *Glomerella cingulata* as well as with the group of *Colletotrichum destructivum* isolates. The spores of the lespedeza isolate seem to be more like the conidia of *C. destructivum* than those of *Glomerella cingulata*. The spores of the lespedeza isolate and those of *Colletotrichum destructivum* were parallel-sided, tapered at the basal end and rounded on the apex. The conidia of *Glomerella cingulata* begin to curve at the middle of the spore, and both ends are similarly curved. In the examination of a range of isolates of *Colletotrichum destructivum* under varying conditions, the pigmentation, septation, and length of the setae have been found to vary so widely with the age of the culture and conditions under which it has been grown that little emphasis can be placed upon them as stable characteristics that would delimit a species.

When apples were inoculated with conidia of the lespedeza isolate and held in a moist chamber, no fruit rot developed. Typical bitter rot was produced, however, by both the kudzu isolate and an isolate of *Glomerella cingulata* from apple.

COLLETOTRICHUM LINDEMUTHIANUM (Sacc. & Magn.) Briosi & Cavara, 1889. Funghi parasiti della planti cultivate ed utile. No. *50*. Pavia, Italy.

Gloeosporium lindemuthianum Sacc. & Magn. 1878. Michelia **1**: 129.

Acervuli scattered, surrounded by a few not very conspicuous black setae; conidiophores cylindric, simple, 45–55 μ long. Conidia oblong, ends rounded, straight or curved, 15–19 × 3.5–5.5 μ.

On pods, stems and leaves of *Phaseolus vulgaris* L. forming subelliptic to irregular depressed spots with dark brown margins.

The organism which causes anthracnose of common garden bean was observed in 1875 by Lindemuth at Popplesdorf, Germany and was first described by Saccardo and Magnus as *Gloeosporium lindemuthianum*. Setae were observed in the acervuli, and Briosi and Cavara proposed the name *Colletotrichum lindemuthianum*. The disease may affect all aboveground parts of the plant, but it is especially noticeable on the pods, where characteristic sunken spots with a light center surrounded by a darker border occur. Several strains of this fungus have been differentiated on the basis of reaction of host varieties.

Two isolates, the alpha and gamma strains, have been obtained from Dr. G. C. Kent, Ithaca, New York. Several isolates were obtained from diseased bean pods from home gardens in Ames. Both the alpha and gamma strains were primarily mycelial, either on artificial media or on sterilized soybean stems. Some conidia were produced.

The local isolates produced a somewhat sparse vegetative mycelium on potato dextrose agar, and well organized acervuli were formed over the surface of the colony. If frequent transfers were not made, however, abundant gray aerial mycelium was formed, and transfers made from it were predominantly mycelial. By using spores as transfer inoculum, and transferring every week or two, an actively sporulating isolate could be maintained. Conidia were straight with rounded ends, 13.6–18 × 3.5–5.1 μ (FIG. 12). Attempts to inoculate any plant species other than varieties of *Phaseolus vulgaris* were unsuccessful. Also, none of the other *Colletotrichum* species were successfully established on garden bean.

DISCUSSION

In a study of the species of *Colletotrichum* on legumes, the investigator is confronted with the problem of establishing a proper concept of the species. A brief glance at the literature of pathology and mycology is all that is necessary to convince one that no uniform criteria for acceptance of such limitations exist. On the one hand, in the case of parasites, the host becomes determining, a concept that was particularly prevalent before the extended use of the pure culture; on the other hand, morphological identity became the criterion, despite the occurrence of the fungi on widely separated species, genera or even families of hosts. In the latter case, limits of variability are laid down and the fungus identified therefrom. With the advent of pure culture techniques the first concept broke down somewhat when it was shown that a fungus could attack and successfully maintain itself on several host species. The converse

of this situation; that is, the situation in which the host is attacked by several closely related species, has been accepted much more tardily. Investigators when identifying pathogens have been too disposed to lean upon the host-index for their determinations and hence to overlook or disregard specific differences that would lead them to consider the fungus at hand a species that was not reported on the particular host they were studying. Such determinations have led to confusion either by lumping too many species under a single name or by multiplying the number of "biologic races" that were in reality distinct and valid species. Recently the insistence on morphological similarity was questioned when Fischer and Shaw (**12**) found in the genus *Urocystis* morphologically identical entities in a group highly specialized in its parasitic relations on hosts in separate families of plants. Could or should they be considered a single species or were their host relations, method of parasitism and physiologic specialization such that they should be treated as distinct species? They decided that in the Ustilaginaceae morphologically similar parasites on hosts of different families should be dealt with as different species. Should such a dictum be transferred to a genus like *Colletotrichum*, species of the *Colletotrichum* on alfalfa could not be considered as *Colletotrichum graminicolum* no matter how closely they resembled that species morphologically and the *Colletotrichum* from tobacco reported by Johnson and Valleau (**17**) could not be *C. destructivum* as it was identified. In order to confuse the issue further, Weimer and Dunegan (**33**) report field occurrence of *Glomerella cingulata*, originating from peach, on lupine. Cross inoculations confirmed the identity of the fungus. In this case the dictum of Fischer did not hold and we may conclude that, in the case of the anthracnose fungi, in which group parasitism is somewhat less specialized, the host limitations are also less precise. Hence it should not be improbable that *Colletotrichum destructivum* might attack tobacco or *C. graminicolum* attack clovers and alfalfa.

The ability of a parasite to establish itself on hosts other than its usual or common one leads naturally to the danger of epiphytotics occurring when a new but related species of host is introduced into our agricultural program. In the area of investigation covered by this paper we have an excellent illustration. The anthracnoses of clover and lima bean have been well-known for many years on these hosts. When the soybean was introduced and became a widely planted crop in areas where clover, alfalfa and lima beans were already well established in the cropping systems, *Colletotrichum truncatum* and *C. destructivum* both were able to maintain themselves on this new host and produce diseases of economic significance. The fact that *Glomerella glycines*, the ascigerous stage of

SUMMARY OF SOURCES AND HOST RANGE OF SPECIES OF COLLETOTRICHUM FROM LEGUMES

Fungus	Host	Source	Conidial measurements (in μ)	
			Length	Width
STRAIGHT SPORE GROUP				
**C. trifolii*	Red clover		11.0–13.0	3.0–4.0
*C. trifolii (J371)***	Alfalfa	Madison, Wisc.	10.5–12.9	3.5–4.0
C. trifolii (3017)	Alfalfa	Beltsville, Md.	10.5–11.5	3.5–4.0
C. trifolii (3020)	Alfalfa	Beltsville, Md.	10.5–11.5	3.5–4.2
C. trifolii (J357)	Sweet clover	Madison, Wisc.	10.5–11.9	3.5–4.0
**C. destructivum*	Red clover		14.0–22.0	3.5–5.0
C. destructivum	Red clover	Ames, Iowa	14.0–17.8	3.5–4.5
C. destructivum (118)	Red clover	Marshalltown, Ia.	15.8–19.3	3.5–4.5
C. destructivum (2939)	Red clover	Stratford, Va.	15.8–17.5	3.5–4.5
C. destructivum	Sweet clover	Ames, Iowa	14.0–17.5	3.5–4.5
C. destructivum (IC4)	Sweet clover	Illinois	17.5–19.3	3.5–4.5
C. destructivum	Alfalfa	Ames, Iowa	14.0–19.2	3.5–4.5
C. destructivum (J402)	Alfalfa	Lincoln, Nebr.	14.0–17.5	3.0–4.5
C. destructivum (J351)	Alfalfa	Wisconsin	17.5–21.0	3.0–3.5
C. destructivum (J335)	Alfalfa	Wisconsin	14.0–17.5	3.0–3.5
C. destructivum (3432)	Alfalfa	Columbus, Ohio	15.8–19.3	3.5–4.5
C. destructivum (64)	Alfalfa	Iowa	17.5–19.3	3.5–4.5
C. destructivum (2800)	Alfalfa	Leland, Miss.	15.0–20.5	3.5–4.5
C. destructivum	Soybean	Iowa	14.0–17.5	3.5–4.5
C. destructivum	Peas	Wisconsin	16.1–23.8	3.0–4.0
C. destructivum (192)	Vetch	Louisiana	15.8–22.8	3.5–4.5
C. destructivum (192Y)	Vetch	Louisiana	14.7–21.0	3.5–4.0
Glomerella glycines	Soybean	Ames, Iowa	16.3–18.0	3.5–4.5
**Glomerella cingulata*			10–28	3.5–7.0
G. cingulata	Kudzu	Georgia	8.5–13.6	3.5–5.5
**Colletotrichum lindemuthianum*	Garden bean		15–19.0	3.5–5.5
C. lindemuthianum	Garden bean	Ames, Iowa	13.6–18.0	3.5–5.1
CURVED-SPORE GROUP				
**Colletotrichum truncatum*	Lima Bean		21–29.8	3.5–4
C. truncatum	Lima Bean	North Carolina	21–30	3.5–4
C. truncatum	Soybean	Iowa	24.2–30	3.5–4
C. truncatum (2522)	*Lotus purshianus*	San Antonio, Texas	17.1–21.0	3.5–4.5
C. truncatum (2523)	*Lotus americanus*	San Antonio, Texas	17.5–26.2	3.5–4.5
C. truncatum (2524)	Alfalfa	Raleigh, N. C.	21.0–31.5	3.5–4.5
C. truncatum (102)	Red clover	Ames, Iowa	19.3–24.5	3.5–4.5
C. truncatum (106)	Red clover	Tama, Iowa	24.5–28.0	3.5–4.5
**C. viciae*	Vetch		17.0–21.0	3.0–4.0
**C. glycines*	Soybean		16.0–25.0	3.7–4.5
**C. villosum*	Vetch		15–24	3.5–4.5
C. villosum	Vetch	Georgia	16.5–21.0	3.5–4.5
**C. graminicolum*			18–26	3.5–4
C. graminicolum (1747)	Alfalfa	Madison, Wisc.	21–31.5	3.0–3.5
C. graminicolum (74)	Alfalfa	Ames, Iowa	21–28	3.0–4.0
C. graminicolum	Alfalfa	New Mexico	25.6–31.5	3.0–4.0
C. graminicolum (22)	Sweet clover	Ames, Iowa	21.7–28.0	3.0–3.5
C. graminicolum	Ladino clover	New Mexico	25.2–31.0	3.0–4.0
C. graminicolum	Oats	Ames, Iowa	21.7–28.0	3.0–3.5

* Dimensions from original descriptions.
** See text for significance of numbers.

Colletotrichum destructivum, has not yet been found in China supports the above hypothesis.

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SOME LEAFSPOT FUNGI ON WESTERN GRAMINEAE. VII [1]

RODERICK SPRAGUE

(WITH 1 FIGURE)

All of the specimens discussed in this paper were collected in southeastern Alaska during July and August, 1952. The primary purpose of the trip was to study "The development of vegetation and soil on deglaciated terrain in southeastern Alaska." This trip was financed by the U. S. Office of Naval Research, the American Geographical Society, and the Graduate School of the University of Minnesota. Many facilities were provided by the U. S. Forest Service. The expedition was staffed with personnel loaned by the State College of Washington and the University of California under the leadership of the organizer of the expedition, Donald B. Lawrence [2] of the University of Minnesota. Since the writer had sufficient time to collect about 500 specimens of diseased grasses during the seven weeks, in addition to his duties as general mycologist for the expedition, he has assembled this separate paper on some of the new or noteworthy gramineous fungi found in the first 250 packets examined.

The specimens were obtained in the vicinity of Juneau and in the unmolested Glacier Bay National Monument to the west of Juneau. The vascular vegetation and flora of the latter area have been studied by Cooper (**6**, **7**, **8**, **9**) but this vast stretch of recently deglaciated shore line has apparently not been visited by collecting mycologists for many years.

[1] Scientific Paper No. 1221, Washington Agricultural Experiment Stations, Pullman. Project No. 449.

[2] The writer is indebted in many ways to Dr. Lawrence for aid during the course of the work. He also thanks his colleagues of the summer of 1952, Robert Crocker, Elizabeth Lawrence and Roland Schoenike, for their splendid cooperation, which included help in the collection and preservation of specimens under often adverse conditions. The writer's participation in the expedition would not have been possible without the cooperation and aid of Director Mark T. Buchanan of the Washington Agricultural Experiment Station and of his colleagues, Supt. Archie Van Doren and Gardner Shaw; Mr. B. Frank Heintzleman, Raymond Taylor, and other personnel of the U. S. Forest Service, Juneau, helped in many ways. The Juneau Botanical Club provided some of the leafspot material from its herbarium.

A recently published check list on western grass and cereal disease by Fischer and the writer (**18**) antedates the work done in 1952 and it points to the paucity of reported Alaskan collections up to 1953. There were only 49 citations of fungi on Gramineae (hosts × fungi) for all of Alaska while, comparably, North Dakota has 1506 such citations. However, a report by Cash (**5**), still more recently issued, adds 129 citations to her earlier list of gramineous parasitic Alaskan fungi (**4**). In addition our card index, as of this date (March, 1953), adds 81 more to Cash's list. This makes a total of 254 citations from Alaska on Gramineae to date. Therefore, in the course of a few months, the Alaskan list has expanded several times. In our current studies it has been rarer to find a fungus that was not new on the host, or for that matter not new to the Territory, than to find one that was new. In this paper no attempt is made to make this an annotated check list. Only new or otherwise noteworthy fungi are included.

Gloeocercospora alascensis sp. nov.

Maculis stramineis, aenea-aureis v. griseis, sub-zonatis, elongatis; sporodochiis superficialibus, hypophyllis, albidis, hyphis hyalinis, septatis, aggregatis, conidiophoris hyalinis, tenuibus; sporulis albis, massa lentis, hyalinis v. chlorinis, cylindraceo-fusiformibus, apicis acuminatis, basis sub-obtusis, prope bases in paribus unitatis, 13–19.2× 1.8–2.5 μ, 1–3-septatis.

Hab. in foliis vivis *Triseti spicati* (L.) Richt., Muir's Camp, Glacier Bay, Alaska. Legit. R. Sprague A.S. *33,514(726)*.[3]

Spots straw-colored to copper buff or edged with gray, subzonated, elongated or coalesced, mostly occupying entire width of leaf and sometimes several inches of its length; sporodochia hypophyllous, superficial, shallow, white, composed of intertwined or aggregated hyaline hyphae; conidiophores simple, short, 5 μ tall, 1–1.5 μ diam.; spores in white, slightly sticky masses, narrowly fusoid below the center, attached in pairs, with blunted bases nearly touching and the pointed apices flared apart, hyaline or chlorinous, 13–19.2 × 1.8–2.5 μ, 1–3-septate.

On living leaves of *Trisetum spicatum* (L.) Richt. At Muir's Camp, Glacier Bay National Monument, Alaska, in small prairie-like openings in willow thicket near small creek in glacial outwash. Aug. 18, 1952. This area lay about 150 yards from the site (**12**) of the naturalist John Muir's cabin.

[3] A.S. refers to the Accession Series, Dept. of Plant Pathology, Washington State College, where all of the material discussed in this paper is, or will be, filed. The smaller number in parentheses (*726*) refers to the writer's temporary field packet number.

When this material was collected, there was an abundance of relatively prominent masses of white spores present in the leaf lesions. The fungus was unfamiliar to me and I made special note of the spore masses. The ever-present insects devoured most of the masses which also dried down considerably. The fungus is very difficult to classify satisfactorily. We have had abundant material of *Gloeocercospora* from Mexico for comparison and have also studied the literature in detail, especially illustrations of *Titaeospora, Ramulispora* and *Gloeocercospora* (**1**, **2**, **13**, **15**). It is our conclusion that the spores are not branched but fused as in *T. detospora* (Sacc.) Bubak (**2**). The formation of the shallow sporodochial pad is like *Gloeocercospora*. The spores in *G. alascensis* are appreciably smaller than those of *G. sorghi* Bain. & Edg., with relatively few septations and with less tendency to form slimy spore masses. The coppery tints are largely absent in *G. alascensis*.

Because the material was overheated in the communal drying oven in the galley on M. S. Taku the spores are in no condition to reproduce in line drawings.

Mycosphaerella deschampsiae sp. nov.

Maculis stramineis, emarginatis; peritheciis subseriatim ordinatis, subcuticularibus, globosis, ostiolatis, brunneis, parenchymaticis, 65–95 μ diam.; ascis clavatis, 25–30 × 10.5–12 μ; ascosporulis 8, hyalinis, cylindraceis, 1-septatis, 11–13 × 2.8–3.4 μ.

Hab. in foliis vivis *Deschampsiae atropurpureae* (Wahl.) Scheele, Mendenhall Glacier, Alaska. Legit. R. Sprague (*188*), A.S. *33,539*.

Spots straw-colored on margin of living leaves; perithecia numerous, more or less in lines, subcuticular, globose, ostiolate, brown, poorly developed, with coarse parenchymatous cells, mostly immature, 65–95 μ diam.; asci short, club-shaped to almost elliptical, not numerous, 25–30 × 10.5–12 μ; ascospores hyaline or bluish-hyaline, cylindrical but with the upper cell somewhat larger than the lower, slightly constricted at the 1 septum, 11–13 × 2.8–3.4 μ.

On living leaves of *Deschampsia atropurpurea* in deep spruce-hemlock woods which date back to about 1800 A.D. on a moraine in the Mendenhall Glacier area of the Mendenhall River valley (Crocker station 13).[4] A.S. *33,539*, July 15, 1952 (type).

[4] Refers to Robert Crocker's station number on one of the glacial moraines where he obtained soil for nitrogen analysis. Each station has a known date, based largely on number of tree rings, in elapsed time since the ice receded from the particular spot (station). Some of these stations bear Crocker's number, some of them Lawrence's and some in the Glacier Bay area refer back to the earlier ecological work by Cooper (cfr. **6**). A few bear the writer's station number. In all cases a relatively complete survey of all kinds of fungi was made by the writer at each of these

The scanty but adequate specimen may be slightly immature but the spores are almost, if not completely, mature. In addition to the ascospores, there are some spores which resemble those of *Ovularia pusilla* (Ung.) Sacc. & D. Sacc. which are associated with the spots. Their relation to the other fungus is not clear.

M. deschampsiae appears to be parasitic. Its development on current-season tissue is unusual but not unheard of, especially in Alaska, where many of the ascigerous forms do not require overwintering in order to produce mature asci. Along this line, the fungus was compared with *M. calamagrostidis* Greene which Greene found on living green tissue at the height of the growing season. (**11**). His fungus had asci 50–60 × 12–15 μ and spores 15–17 × 4–5 μ in black pycnidia, 125–160 μ. Our fungus is smaller on all counts than *M. calamagrostidis*.

Septoria macropoda f. **sitadakaensis** f. nov.

Maculis stramineis, emarginatis; pycnidiis brunneis, erumpentibus, globosis, parenchymaticis, ostiolatis, 135–170 μ; pycnidiosporulis hyalinis, obclavatis, apicis, acutis, basis sub-obtusis, 3-septatis, 29–52 × 1.7–2.3(–2.9) μ.

Hab. in foliis emortuis, basis culmorum *Poae paucispiculae* Scribn. et Merr., Sandy Cove, Glacier Bay, Alaska.

Spots straw-colored to dead-leaf brown, without definite margin, pycnidia scattered, obscure, brown, erumpent, ostiolate, globose, parenchymatous, 135–170 μ diam.; pycnidiospores hyaline, narrowly obclavate, apices acute, bases sub-obtuse, spores somewhat curved to sinuous, mostly 3-septate, 29–52 × 1.7–2.3(–2.9) μ.

In necrotic basal foliage of living plants of *Poa paucispicula* growing on a shady limestone cliff above Sandy Cove, Glacier Bay National Monument, Alaska. A.S. *33,551,* Aug. 18, 1952.

The name is derived from the old Hoonah Indian name for Ice Bay, what is now the Glacier Bay National Monument. The immediate vegetation was alder and willow although a spruce-hemlock forest was developing rapidly over most of the vicinity. The fungus is somewhat intermediate between *S. macropoda* var. *septulata* (Frag.) Sprague and *S. macropoda* var. *grandis* Sprague but differs from them in having spores with thicker bases, much like some collections of *S. andropogonis*.

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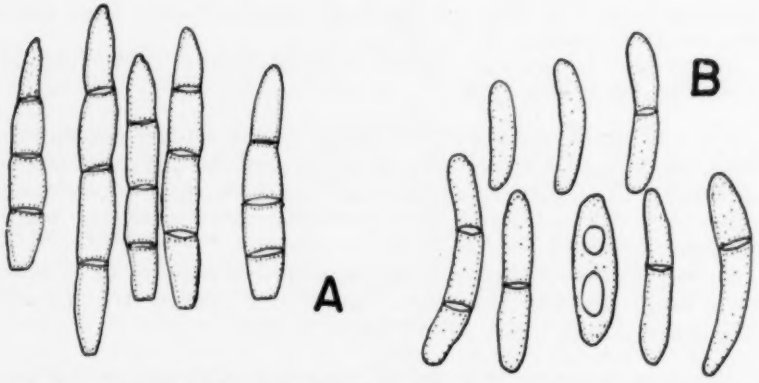
stations. The present taxonomic study of Gramineae is therefore partly a by-product of the over-all study on fungus ecology which in turn is a part of the studies of the entire expedition on relation of nitrogen to revegetation of deglaciated areas in southeastern Alaska. The place names mentioned for Glacier Bay National Monument appear on maps published by Cooper (**7**) and by Field (**10**).

The collection appears to belong in the *S. macropoda* complex but should be segregated from the recognized variants of this species.

SEPTORIA AVENAE Frank, with somewhat small yellowish spores (16–30 × 2.9–3.8 μ) (FIG. 1, a), was found in light brown to brown lesions on living leaves of *Agrostis borealis* Hartm. at timberline on Gastineau Pk. near Juneau (A.S. *33,545*). It was collected with material of *Mastigosporium rubricosum* (A.S. *33,544*). What makes this *Septoria* so difficult to classify is the fact that the spores vary from subhyaline to yellow-brown. They are scarcely distinguishable from *Hendersonia culmicola* Sacc. which is a common saprophyte on alpine grasses in the Rocky Mountains. We are inclined, because of the apparent parasitic nature of the fungus, to consider them arctic-influenced, perhaps oxidized, spores of the usually hyaline-spored *S. avenae*. The black pycnidia are numerous, not only in the lesions but on dead leaves as well. Until such material can be cultured and critically studied the above disposition must be made of it.



All drawings made with the aid of the camera lucida and reproduced at a magnification of approximately × 1600.

FIG. 1, A. Pycnospores of *Septoria avenae* Frank on *Agrostis borealis* Hartm., Gastineau Pk. (A.S. *33,545*). B. Aberrant spores of *Rhynchosporium orthosporum* Caldwell on *Calamagrostis canadensis* var. *scabra*, Herbert River area (A.S. *33,541*).

For the convenience of the herbarium worker we segregated this material into two parts; one is filed as A.S. *33,544* under *M. rubricosum* and the other as A.S. *33,545* under *S. avenae*, although both fungi occur to some extent in both packets, as is indicated on them.

Typical *S. avenae*, with narrowly cylindrical, 3-septate, hyaline spores, was collected on *Agrostis exarata* Trin. on the south fork of Eagle River

(A.S. *24,361*) and at Beartrack Cove, Glacier Bay National Monument (A.S. *33,548*).

SEPTORIA JACULELLA Sprague (**17**) was common on a new host, *Bromus sitchensis* Trin., along the beach at Hoonah, Alaska (A.S. *33,547*). The prominent pycnidia measured 150–260 μ and the spores were also typical in size (48–61 × 2.5–4.0 μ), shape and color. This collection extends the range north from Washington State.

SEPTORIA TENELLA Cooke and Ellis caused a drab sheath spot on living plants of *Festuca ovina* var. *brachyphylla* (Schult.) Piper along the south fork of the Eagle River (A.S. *24,377*). The spores were hyaline, 1-septate, base blunt, apex slightly pointed, 13–20 × 1.5–2.1 μ. They resembled, therefore, some material collected on *F. dertonensis* in Oregon a number of years ago (**17**). They also showed similarity to *Septoria passerinii* which is common on wild *Hordeum* in the Tongass National Forest area. Because of the earlier detailed studies which disclosed the polymorphic nature of the west coast phase of *S. tenella* this Alaskan material is placed there also. *S. tenella* is unreported on this alpine variety of sheep fescue and is unreported from Alaska as of this writing although it has been found in great abundance in the coastal area of Oregon and in the Rocky Mountains. The region where the Alaskan material was found is completely virgin and undoubtedly the fungus is native.

Septoria tenella was also collected on *Festuca rubra* L. on the beach at Sandy Cove, Glacier Bay National Monument, Aug. 18, 1952 (A.S. *33,519*). The spores were very long, up to 105 × 2.9 μ, but they were collected during a prolonged rainstorm and no doubt were partially germinated before drying. The pycnidia were typical for the species and smaller *Ascochyta*-like spores were present, as in most of the coastal material of this species. The fungus was exceedingly abundant on the lush red fescue growing on the beaches in the general area.

SEPTORIA PACIFICA Sprague was found on leaves of *Elymus mollis* Trin. on the beach at Beartrack Cove, Glacier Bay National Monument, Aug. 23, 1952 (A.S. *24,397*) (*919*). The extremely long, slender spores, up to 90 × 2.8 μ, were typical for the species (cfr. **15**, Fig. 43,a). This is the first known report of this fungus north of coastal Oregon. Associated with this material was *Colletotrichum graminicola* (Ces.) Wils. with spores 20–24 × 2.5–5.0 μ. I can find no report of anthracnose on this beach grass.

SEPTORIA AGROPYRINA Lobik was abundant on *Elymus mollis* at Auk Village Recreation Area near Juneau, Alaska, collected on July 16, 1952 (A.S. *33,529*). When collected it was assumed that this would prove

to be the same as *S. pacifica* but study disclosed that the material was very distinct in morphology. The spots on the leaves were mottled, later fading to straw-colored areas. The pycnidia were large, black, and as much as 200 μ in diam., sunken and more or less in lines. Sometimes they were numerous enough to give a dark color to the lesions. The spores were obclavate, pointed at the apex and blunter at the base. The spores were 3–7-septate and as much as 89 μ long and 3.5–4.2 μ wide. The spores appear much stouter than those of *S. pacifica* and are less curved. We have seen similar material in the Great Plains on *Elymus* spp. and *Agropyron* spp. and on *E. glaucus* in Oregon. The Alaskan material differs from any other seen in the presence of 7-septate spores. Apparently the abundant food supply in this favorable environment permitted an extra division of cells, therefore increasing the number of cells from the usual three to seven. The worker considering this fungus must compare it with *Septoria infuscans* and *Stagonospora arenaria* as well as with *S. agropyrina*. The latter was chosen because of the shape of the spores.

SEPTORIA MACROPODA Pass. occurs on *Poa annua* L. along an abandoned wagon road between Herbert River and Eagle River on the road to Yankee Basin, Tongass National Forest (A.S. *33,584*). The pycnidiospores are larger than average but readily assignable to the species proper.

SEPTORIA OUDEMANSII Sacc. was found on *Poa arctica* R. Br. near Herbert Glacier on land exposed by the melting ice about 1930. The purple-brown elliptical leafspots were surrounded by a yellowish halo. The spores are distinctly coarser than those of the 1-septate phase from Oregon and Washington. The oil drops in the Herbert Glacier fungus are much coarser than the small uniformly spaced ones in the Washington and Oregon collections (**15**, Fig. 42). The Alaskan material is closer to *S. oudemansii* than to *S. nodorum*. Another collection on *Poa arctica* was found above timberline on Gastineau Pk. (A.S. *33,560*) with spores typical of *S. oudemansii* from further south.

A fungus was found on *Poa stenantha* Trin. (viviparous form) at Muir's Camp, Glacier Bay National Monument, with small yellow-brown pycnidia (70–85 μ) containing cylindrical microspores, 9.5–13 × 1.2–1.9 μ (A.S. *33,509*). The pycnidia were in lines along the culms and sheaths and were associated with vague tawny spots. The microspores were associated with a few spores 10–16 × 1.9–2.6 μ which somewhat resembled *S. oudemansii*. The microspores and macrospores resembled atypical material of *S. infuscans*, illustrated earlier (**15**, Fig. 35,e), and also were like *S. microspora* (**15**, Fig. 44,d) which is a microspore phase of

S. passerinii. I am inclined to consider the material from Muir's Camp as somewhat aborted material of *S. oudemansii* forced into the microspore stage during an earlier very dry period followed by a wet period. This has been the history of comparable material studied in some detail earlier (**17**).

S. oudemansii occurs with *Darluca filum* (Biv.) Cast. and *Puccinia poae-sudeticae* (West.) Jorstd. on *Poa alpina* L. at Muir's Camp. The fungus in this material appears more nearly normal. The slender spores of the *Septoria* measured 18–23 × 2.3–2.8 μ (A.S. *33,557*). We also noted a trace of *S. oudemansii* on old basal leaves of *Poa epilis* Scribn. high on the slopes of Gastineau Pk. It was associated with *Hendersonia crastophila* Sacc. (A.S. *33,565*).

MICROTHYRIUM CULMIGENUM Sydow was found on the sheaths of *Poa stenantha* at about 2000 ft. elevation on Red Mountain, Glacier Bay National Monument, Aug. 12, 1952 (A.S. *33,532*)(*613*). The peculiarly flattened, carbonaceous perithecia (thyriothecia) measured 130–160 μ in diam. and the asci were 34–40 × 7.5–8.5 μ but were either immature or, more likely, plasmolyzed by excessive heat during drying. The morphology of the spores could not be definitely determined in this condition; but they appeared to be somewhat fusiform, hyaline or yellowish and about 10–14 μ long. The fungus is close to *M. culmigenum.* I have studied the papers by Webster and have concluded that our material is different from *M. gramineum* Bomm., Rouss. & Sacc. and from *M. nigro-annulatum* Webster (**19**, **20**). Seymour does not list any *Microthyrium* on Gramineae from North America (**14**). This is hard to understand, because the fungus is common in Alaska and probably elsewhere in the northern area. Webster records *M. culmigenum* from England on *Arrhenatherum, Dactylis, Holcus mollis* and oats stubble (*Avena*). The type of *M. culmigenum* is *Calamagrostis lanceolata* (Petrak Myc. Gen. *1325*, Brandenburg, Germany).

M. culmigenum is saprophytic. It occurs on current-season dead sheaths and leaf bases. On A.S. *33,532*, above noted, we also found *Heterosporium avenae* Oud., *Mycosphaerella tulasnei* (Jancz.) Rothers and *Ascochyta sorghi* Sacc. This last mentioned was found on a few leaf tips which were removed and filed separately as A.S. *33,533*. The spores measured 11–14 × 1.8–2.8 μ and were typical of *A. sorghi.*

M. culmigenum was also found on basal leaves of *Phleum alpinum* L. in a recently filled (glacial outwash) lake bed at about 1100 ft. elevation on Red Mountain, Glacier Bay National Monument (A.S. *33,534* and *33,554*). The fungus was also found on *Agrostis scabra* var. *geminata*

(Trin.) Swallen at 3600 ft. elevation on Red Mountain (A.S. *33,536*), above the glacial trimline.

SELENOPHOMA DONACIS VAR. STOMATICOLA (Bauml.) Sprague & A. G. Johnson was common on *Poa stenantha* Trin. (A.S. *33,553*), growing in glacial outwash under low-growing *Salix alaxensis* (Anderss.) Cov. in an isolated area near Russell Island on Reid Inlet, Glacier Bay National Monument. The area is pin-pointed as Cooper Station 26 (**6**). The spores in this material were strongly arcuate to semi-boomerang shape, 13–19 × 1.9–2.8 μ. The small black pycnidia were abundant on the leaves and sheaths. Similar collections have been seen from Greenland and from the Rocky Mountains on *Poa* spp.

SEPTOGLOEUM OXYSPORUM Sacc., Bomm. & Rouss. occurs on living leaves of *Agrostis aequivalvis* (Trin.) Trin. near Satko's cabin near the Herbert River, Tongass National Forest (A.S. *24,384*). The spores are light yellow, fusiform-cultiform with two septations towards the end of the spores. There appears to be no report of this fungus north of Washington State, as of this writing. I have seen similar material on *Agrostis hallii* Vasey in Oregon (**15**). The fungus was also found on *Agropyron subsecundum* (Lk.) Hitchc. at Sandy Cove, Glacier Bay National Monument (A.S. *33,570*). It caused a char spot on this host but without appreciable spore production. It was associated, in part, with *Puccinia rubigo-vera* (DC.) Wint. (A.S. *33,569*).

DARLUCA FILUM (Biv.) Cast. is a common parasite on rust in southeastern Alaska. I mentioned its presence in association with *Septoria oudemansii* earlier in this paper. It was especially prevalent on *Puccinia poae-sudeticae* on *Poa stenantha* in the bleak recently deglaciated area along Goose Cove Creek near Muir Glacier, Glacier Bay, Alaska.

SCOLECOTRICHUM GRAMINIS Fckl. is not uncommon in Alaska, especially on *Calamagrostis canadensis* var. *scabra* (near Auk Village, A.S. *33,537*; *33,538*; Herbert River area, A.S. *33,546*). Very frequently prosenchymatous structures form under the conidial tufts. The immature fruiting body, probably ascigerous, rises beneath the conidial tuft and slowly forces it apart. The tuft is retained as a somewhat evanescent collar on the fruiting body which in mid-late summer resembles an eroded pycnidium with a wide mouth.

RHYNCHOSPORIUM ORTHOSPORUM Caldwell is widespread but only moderately destructive on *Calamagrostis canadensis* var. *scabra* in southeastern Alaska. A large number of specimens are available from the Juneau area. The fungus causes interrupted linear to eyespot-shaped discolored lesions on plants growing in the open or in the shade of salmonberry, blueberry, or alder. The spores are usually identical with

those illustrated by Caldwell (**3**) but some collections are atypical. The spores in these are small and somewhat curved, while each cell contains one relatively large oil drop. This material is somewhat like *R.* sp. on *Elymus glaucus* from Oregon (**15**, Fig. 77,b). In addition to this kind of material we have one collection from the Herbert River (A.S. *33,541*) with many curved, 1–2-septate spores 11–17 × 2.5–4.0 μ. Some of these resemble miniature spores of *Septogloeum oxysporum* while others are like *Fusarium* spores, less their heels. Other spores are somewhat allantoid or elliptical with two coarse oil drops (FIG. 1, b). This is only further evidence of the polymorphic nature of *R. orthosporum* (**15**, **16**).

R. orthosporum and *R. secalis* were both noted on *Agropyron subsecundum* (Lk.) Hitchc. The collection of the first mentioned made at Sandy Cove, Glacier Bay National Monument (A.S. *33,568*), was similar to Utah material seen on this grass. The spores were cylindrical, except for a few that tended to have the ends slanted slightly (**11**). This material is certainly intermediate morphologically between *R. orthosporum* and *R. secalis*. Typical *R. secalis* was seen on this grass at the terminal moraine area (Lawrence Sta. 5) in the Mendenhall valley (A.S. *24,398*) and along the Yankee Basin trail, Tongass National Forest (A.S. *33,520*).

R. orthosporum was noted on *Agrostis exarata* Trin. near the lower parking area at Mendenhall Glacier Steep Creek picnic area (A.S. *33,559*). This is apparently an unreported host. The grass may be resistant. At least the lesions are few and not well formed in this collection.

MASTIGOSPORIUM RUBRICOSUM (Dearn. & Barth.) Nannf. was found on *Trisetum cernuum* Trin. at Satko cabin, near Herbert River (Sprague *375*). A few light brown elliptical spots occurred on the leaves. The material was very similar to that found in Oregon near the coast on the same host (**15**). The 3-septate, muticate spores of the Alaskan collection were not mature. They measured 30–40 × 13–15 μ. Very similar material was collected on *Agrostis borealis* Hartm. (A.S. *33,544*) at timberline on Gastineau Pk. near Juneau on July 18, 1952. The fungus was also found on *Phleum alpinum* L. a short distance below the last mentioned on Gastineau Pk. The leaves were thickly sprinkled with nearly circular spots less than 1 mm diameter. The bleached spots had conspicuous tawny borders. A few spores were found in the material (A.S. *33,563*). *M. rubricosum* occurs on *Phleum pratense* L. in Washington and Idaho but there are no earlier reports of this fungus on *P. alpinum* in western North America.

M. rubricosum caused a tawny mottling on leaves of *Calamagrostis canadensis* at Beartrack Cove, Glacier Bay National Monument (A.S. *33,574*). The spores measured 35–56 × 12–15 μ and they were definitely pointed at each end. The somewhat sharper points on the spores were probably due to plasmolysis of the fragile spores.

ASCOCHYTA SORGHI Sacc. has one-septate, faintly tinted spores 8–13 × 3.0–3.5 μ. It occurred on *Poa pratensis* L. near Juneau (A.S. *33,564*).

HELMINTHOSPORIUM VAGANS Drechsl. is an important parasite in southeastern Alaska on cultivated and native *Poa* spp. It is common on *Poa pratensis* and *P. compressa* at Juneau in lawns, parks and waste areas. In one case on *Poa stenantha* growing in an opening in a thicket near the Mendenhall Glacier an ascigerous stage was developing from the conidial lesions as early as July 12. The light and temperature conditions in this region are especially favorable to the formation of ascomycetous stages of leaf-invading fungi.

The chocolate brown lesions of *H. vagans* were very abundant on *P. stenantha* growing in soil pockets on granitic rocks which had been exposed by the retreating ice at Mendenhall Glacier as late as 1947. In these the fungus caused a foot decay as well as sheath and leafspot.

HELMINTHOSPORIUM TERES Eidam occurs on old leaves of *Hordeum brachyantherum* Nevski at Cooper Station 26 (cfr. **6**) near Russell Island, Reid Inlet area of the Glacier Bay National Monument. The material (A.S. *33,549*) shows typical conidiophores of this species and an abundance of developing perithecia comparable to *Pleospora trichostoma* (Fr.) Ces. & de Not. We have material of *H. teres* on this host from the San Juan Islands, Washington (**18**) but this is the first report from Alaska. It is probably common.

TYPHULA sp. was associated with snow mold on basal leaves of *Agrostis scabra* var. *geminata* at 3600 ft. elevation on Red Mountain, Glacier Bay National Monument. The sclerotia were bright apricot or salmon-colored and up to 1 mm in diam., globose to slightly elongate and buried or folded in the basal leaves and sheaths. I have seen this color in young sclerotia of *T. itoana* in late winter in Washington but have never noted that it was retained so strikingly in herbarium material. The fungus was unquestionably parasitic on the grass growing in the exposed area near snow banks which had still not melted by nearly mid-August. Associated were a number of saprophytes including a species of *Leptosphaeria* with sub-cultiform 7-septate spores.

CERCOSPORELLA POAGENA Sprague occurs on *Poa pratensis* L. along the street at Hoonah, Alaska (A.S. *33,584*). The spots are obscure and not clear-cut eyespots as in the Oregon material (**15**) but the spores

are typical (**15**, fig. 70). This is the first report of this fungus outside of Oregon.

OVULARIA PUSILLA (Ung.) Sacc. & D. Sacc. is common in southeastern Alaska. The buff spots are sometimes abundant on *Glyceria pauciflora* Presl in the Tongass National Forest (A.S. *24,345*). It was newly found on *Poa pratensis* L. in virgin country along the south fork of the Eagle River (A.S. *24,380*) and at Tlingit Point, Glacier Bay National Monument (A.S. *33,590*). The spot is common on *Agrostis exarata* Trin. in s.e. Alaska. A specimen on this host at Eagle River near its junction with Herbert River [A.S. *33,555(630)*] had chlorinous egg-shaped spores 10–16 × 6.8–7.6 μ. It was seen once on *A. aequivalvis* (Trin.) Trin. in the Herbert Glacier region.

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THREE NEW SPECIES OF HELICOSPORAE

ROYALL T. MOORE

(WITH 5 FIGURES)

Two of the species here described were encountered in the course of preparing a paper on the North Central Helicosporae (Proc. Iowa Acad. Sci., in press); the third is based on material collected by G. W. Martin and A. L. Welden in Panama during the summer of 1952.

Helicomyces colligatus sp. nov. FIGS. 1, 2.

Coloniis effusis, cerosis, villosulis vel subcrustosis, recentibus rubicundulis, senilibus e conidiis paene omnino compositis et mycelio conidiophorisque in speciminibus non manifestis; juvenibus strato toto de conidiis, mycelio et conidiophoris semiagglutinis composito; conidiis directe e mycelio aut in conidiophoris robustis 45 μ tenus altitudine paritis, semel vel iterum laxe conspiratis, hygroscopicis, ad maturitatem multiseptatis, quaque cella vacuolum magnum aut due minora continente; filo ad utrumque terminum fastigto, termino inferiore, 3.5 μ diam., ad circiter 8 μ in medio expanso, et leviter ad terminum angustato, ad segmenta faciliter contuso; diametro spirarum (32–)50–65 μ.

In ligno putrido, Iowa City, Iowa, 14 April 1934, GWM *1357*, Typus; in herb. SUI. Iowa City, 24 July 1934, GWM *6455;* Big Spring, Missouri, 15 April 1939, GWM *6453*.

Colony effuse, ceraceous, coarsely flocculose or nearly crust-like, pale rose when fresh; when old composed almost entirely of conidia, mycelium and conidiophores not apparent in such specimens; when young the whole stratum composed of semiagglutinated mycelium, conidia and conidiophores; conidia arising directly from the mycelium or else borne on robust conidiophores up to 45 μ tall, loosely coiled 1–2 times, hygroscopic, multiseptate at maturity, each cell containing one large vacuole or two smaller ones; filament tapering at both ends, the basal end 3.5 μ, enlarging to 8 μ in the middle and becoming slightly less at the distal end, easily broken into segments; diameter of coils (32–)50–65 μ.

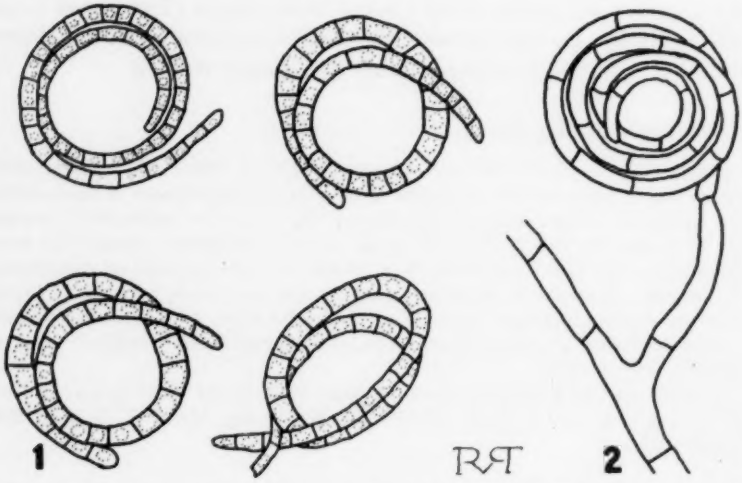
This species is closest to *Helicomyces ambiguus* (Morgan) Linder, in which the thickness of the filament is about the same. However, *H. colligatus* is distinct in that the filament tapers conspicuously toward both ends and is very brittle; the most conspicuous difference, however, is the unique waxy nature of the colonies. Depending on their age, they vary

from somewhat flocculose when young to waxy-crustose, composed almost entirely of conidia, when old.

Helicosporium Linderi sp. nov.

Coloniis effusis, fuscellis; conidiophoris neque floccosis neque arachniodeis sed erectis et separatis, non ramosis, 275 μ tenus altitudine, clare septatis; conidiis pallide fuscis, profusis, pleurogenis, hygroscopicis, diametro spirarum 20–40 μ, filo multiseptato, 3–5 μ crasso, in dentibus conspicuis 2.5–5 × 1.6–2(–3.1) μ.

In folio putrido *Cocos*. Panama Canal Zone, Fort Sherman area, 26 August 1952, GWM *8737* Typus; in herb. SUI.

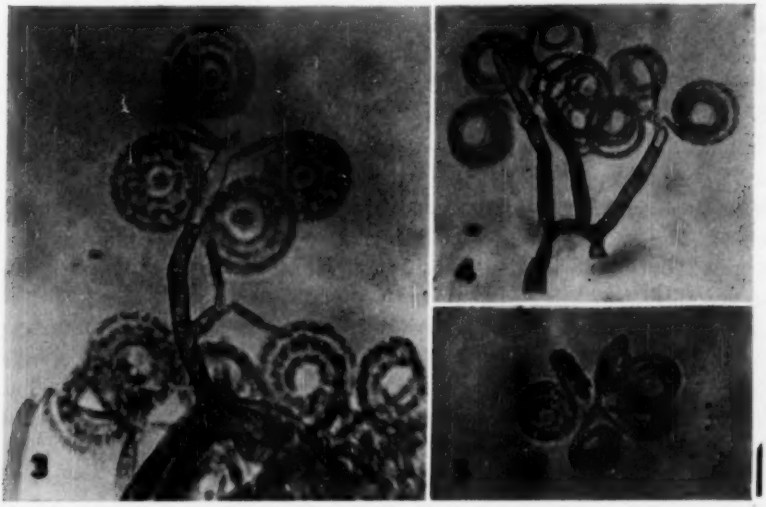


FIGS. 1, 2. *Helicomyces colligatus*. 1. Conidia. 2. Conidiophore bearing young conidium; both × 400.

Colonies effuse, somewhat fuscous; conidiophores neither flocculose nor arachnoid but erect and separate, not ramose, up to 275 μ tall, distinctly septate; conidia pale fuscous, profuse, pleurogenous, hygroscopic, diameter of spiral 20–40 μ, filament multiseptate, 3–5 μ thick, borne on conspicuous teeth 2.5–5 × 1.6–2(–3.1) μ.

The substratum was collected 26 August 1952 and the *Helicosporium* appeared in a moist chamber 15 February 1953. This is a typical *Helicosporium* and it is distinct on the basis of a composite of characteristics rather than a single character. That is, among those species that have a mass color other than yellow or yellowish-green, its filament thickness of 3–5 μ overlaps the primary criterion of thickness more or less than 4.5 μ.

(See Linder's key, Missouri Botanical Garden Annals **16**: 276–277. 1929.) More than 4.5 μ leads to *H. serpentinum*, *H. nematosporum* and *H. Elinorae*, all of which are too robust. Pursuing less than 4.5 μ through conidiophores sparsely branched, conidial coil more than 10 μ in diameter, we arrive at a choice of filaments 1 μ thick, conidiophores sparsely branched below (*H. griseum* and *H. pallidum*), or filaments 1.5–5 μ thick, conidiophores much branched below (*H. albidum* and *H. phragmites*). The former pair is split by *griseum* having clearly septate conidiophores that never anastomose above, while *pallidum* has indi-



FIGS. 3–5. *Helicosporium panachcum*. 3, 4. Conidia and conidiophores, × 435, × 290 respectively. 5. Cluster of six coattached conidia, × 290.

stinctly septate conidiophores that sparsely anastomose above. The latter pair are split by the filament thickness, that of *albidum* being 2–2.5 μ while that of *phragmites* is 1.5–2 μ. Thus it is seen that the validity of *H. Linderi* as a new species rests on characteristics which are actually a different combination of those already present in other species of the genus.

A *Helicosporium* that developed on material collected from the same palm in 1945 was sent to the late Dr. D. H. Linder, who pronounced it undescribed. This material was not returned and its present whereabouts is unknown.

Helicosporium panacheum sp. nov. FIGS. 3–5.

Coloniis effusis, tenuiter arachnoideis, a racemis conidialibus notatis punctatis; conidiis hyalinis, hygroscopicis, in coacervatione albis, acrogenis, numero sex tenus in racemo aut per occasionem singulis, in dentibus robustis 1–2 μ longis; filo tenui, 2.5–4.5 crasso, multiseptato, compacte interum bis quater conspirato, spiris 20–30 μ diam.; conidiophoris 40–70 μ altis, simplicibus aut tenuiter ramosis, rectis aut ascendentibus, septatis, fuscis, cellis terminalibus vivis hyalinis.

In cauli putrido *Zeae maydis*, in vasculo humido, Iowa City, Iowa, September 1951, GWM *6454*, Typus; in herb. SUI.

Colonies effuse, finely arachnoid, punctated by the prominent conidial clusters; conidia hyaline, hygroscopic, white in mass, borne acrogenously with as many as six to the cluster or occasionally singly, on stout teeth, 1–2 μ in length; conidiophores short, 40–70 μ long, simple or sparsely branched, erect or ascending, septate, fuscous, the terminal cell tending to be hyaline; conidial filament slender, 2.5–4.5 μ thick, multiseptate, tightly coiled 2–4 times, the coil 20–30 μ in diameter.

This species is quite similar to *Helicomyces bellus* Morgan, which Morgan describes as "Effused, forming a thin, flocculose stratum, gray with a pinkish tinge. Hyphae creeping, septate, branched, brownish-hyaline [but] bearing the spores on minute lateral teeth." The conidia as described by Morgan are also of comparable size.

While it has no close counterpart in *Helicosporium* it is included in that genus on the basis of the well-developed, short, fuscous conidiophores (the other Helicosporia have conidiophores that at maturity are seldom less than 110 μ long, while *H. panacheum* has a maximum of about 80 μ long), and the conidia which are borne terminally.

Portions of collections have been distributed as follows: *1357*—United States National Herbarium; Herbarium University of California; Royal Botanic Gardens, Kew; Missouri Botanical Garden; New York Botanical Garden; *6453*—Missouri Botanical Garden; *8737, 6454*—New York Botanical Garden.

This work was done in the mycological laboratory of the State University of Iowa under the direction of Prof. G. W. Martin.

I wish to extend my deep appreciation to Dr. D. P. Rogers for his assistance with the Latin.

DEPARTMENT OF BOTANY,
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SOME MYXOMYCETES FROM PANAMA AND COSTA RICA

ARTHUR L. WELDEN

(WITH 8 FIGURES)

The Myxomycetes of Panamá have been studied by Martin (**4, 5**). Standley (**8**) and Weston (**9**) reported on species found on Barro Colorado Island but did not list species found in other parts of Panamá. So far as I am aware there are no published reports on Myxomycetes from Costa Rica. During the summer of 1952 we were able to make additional collections in Panamá and Costa Rica and to add several new reports of species in these areas, as well as range extensions of species previously reported. Only a short time was spent in Costa Rica and nearly all of the collecting was done in the eastern part of the Province of Puntarenas, but several interesting forms were found. In addition to our own collections from Costa Rica, we have several collections communicated by Dr. C. W. Dodge which are also recorded here.

The greater portion of the collecting was done in Panamá, particularly on Barro Colorado Island, located in Gatun Lake in the Canal Zone, which has been set aside by the U. S. Government as the Canal Zone Biological Area. With the exception of the species collected by Dr. Dodge and his associates, all species reported in this paper were collected by Professor G. W. Martin and myself.

The species which are reported here for the first time are preceded by an asterisk; range extensions of species previously reported will have an asterisk preceding the abbreviation of the area in which they were collected. Species which are reported from Costa Rica for the first time and have been reported from Panamá are treated as range extensions.

Abbreviations of the collecting areas are as follows: in Panama—Barro Colorado Island, BC.; Chiriqui Province, Chir.; Panama Province, Pan.; Cocle Province, Co.; Canal Zone (except Barro Colorado Island), CZ.; in Costa Rica—Puntarenas Province, Pun.; Limon Province, Lim.; San Jose Province, SJ.; Cartago Province, Cart.; Guanacaste Province, Guan.; Heredia Province, Her.; Alajuela Province, Ala. The order followed is that of North American Flora (**7**).

***Ceratiomyxa Morchella** sp. nov. (FIGS. 1, 2), BC.

Albis, ca. 3 mm longis, 0.5–2 mm diam., stipitatis; stipite cylindrato, albo vel hyalino, quandoque reducto et capite fere sessili; capitibus globosis vel subcylindratis, similibus *Morchellae*, quandoque fusis; hypothallis nullis vel parvis, hyalinis, membranaceis; sporis hyalinis ad lucem transmissam, ovalibus vel ellipticis, 9–11 × 6–8 μ. Plasmodio ignoto.

FIGS. 1, 2. *Ceratiomyxa Morchella*. 1. Fructification, × 10. 2. Spores, × 500. 3. *Ceratiomyxa sphaerosperma*, spores, × 500. 4, 5. *Didymium verrucosporum*. 4. Sporangium, × 10. 5. Spores, capillitium and lime crystals, × 500. 6–8. *Physarum echinosporum*. 6. Spore, × 500. 7. Portion of the capillitium, × 234. 8. Plasmodiocarp, × 10.

Typus: GWM et ALW *8688*.
Locus typic.: Barro Colorado Island, Canal Zone, Panamá.
Habitat: In lignis putridis.
Distributio: Barro Colorado Island et Chiriqui Province, Panama.

Fructifications powdery white, each up to 3 mm tall, 0.5–2 mm diam., stipitate; stipe cylindrical, white, or hyaline, sometimes reduced and the heads almost sessile, heads globose or subcylindrical, similar to *Morchella*, separate or sometimes fused; hypothallus small, hyaline, membranous or absent; spores white in mass, hyaline by transmitted light, oval or elliptical, 9–11 × 6–8 μ. Plasmodium unknown.

Some of the fructifications are flattened on the surface of the substrate; however, the folded appearance is still evident. This flattening might be the result of handling, as might also be the coalescence of some of the fructifications.

Of the other two collections of this species (GWM & ALW *7713* and *8105*), the first is from Barro Colorado Island also, but is not in very good condition although still recognizable as *C. Morchella;* the other, from Chiriquí, is almost unrecognizable. Portions of this latter collection seem to be reduced to a conspicuous, membranous, hyaline or whitish hypothallus with long curving folds bearing spores, but since this collection has been treated roughly this point will have to await additional

collecting for confirmation. In the meantime it seems best to omit it from the description. Although this species was collected only three times, this does not give a correct indication of its abundance. Numerous small fruitings were seen from time to time on all parts of the Island but were not collected because of their smallness and the failure to recognize at the time what they were.

Portions of the type collection will be deposited in the herbaria of the New York Botanical Garden, Missouri Botanical Garden, United States National Herbarium, State University of Iowa, and the Royal Botanic Gardens, Kew, Surrey, England.

CERATIOMYXA SPHAEROSPERMA Boedijn. (FIG. 3), BC., Lim.

This species was first described by Boedijn (**1**) from Sumatra, fruiting on oil palm. He later reported it from the Krakatau group (**2**). These reports were the only records of this species until Martin (**6**) reported it from Barro Colorado Island occurring on the fruits of *Apeiba* and from Castilla, Limon Province, Costa Rica.

C. sphaerosperma is characterized by its small fructifications, which are composed of a head of several to many, nearly equal, forking branches upon a long, slender stalk, and its globose spores. In the summer of 1952 we were fortunate enough to make another collection of this species on Barro Colorado Island occurring again on *Apeiba* fruit. Upon microscopic examination this collection (GWM & ALW *7304*) proved to be a typical specimen of this species with the exception of its spores which, while globose, were smaller, 7–8 μ, than those listed in North American Flora (**7**). Boedijn reports the spore size as 7.5–8 μ in diam.

In addition to the above collection, many other specimens of *Ceratiomyxa* were found. One of these collections (GWM & ALW *8689*), when examined, has proven to be an exceptional development of *C. sphaerosperma*. It is reduced to a very short series of sporophores borne on a powdery hypothallus which is wholly fertile. The spores of all collections have granular contents (when stained with phloxine), and more or less roughened walls, with one side occasionally thicker than the other. These spore characteristics have not been observed in any collections of *C. fruticulosa*.

These differences seem important enough to warrant a modification of the description:

Fructifications minute, scattered, loosely gregarious, white, composed of a stalk bearing a cluster of arms at the tip, these branched or unbranched, the spore-bearing spicules at the tips of the branches several times as long as those on the sides; stalk tapering downward to substrate,

either erect or recumbent, sometimes absent, then stalk and head reduced to two or three, sometimes more, very short, 0.75 mm or less, united sporophores arising from a more or less continuous, fertile, powdery hypothallus; spores regularly or irregularly subglobose, hyaline, walls even or roughened, with granular contents, occasionally with 1-several guttulae and wall thickened on one side, 6.4–8 μ (av. 7.4 μ).

CERATIOMYXA FRUTICULOSA (Müll.) Macbr. BC., Chir., Co., CZ., *Pun., *Lim.

*LICEA PUSILLA Schrad. BC.

TUBIFERA MICROSPERMA (Berk. & Curt.) G. W. Martin. BC., *Co.

*LYCOGALA EXIGUUM Morgan. BC.

Lister (3) treats this species as a variety of *Lycogala Epidendrum* (L.) Fr. Our collections are well differentiated from that species by their tessellate plates, relatively smoother pseudocapillitial threads and generally smaller spores. All collections were made from rotting wood. The aethalia vary from 1.5–4 mm in diam. with very prominent black warts, mainly on the upper portion of the peridium. Some aethalia are so thickly covered with these warts as to appear black. Spores are mostly 4.8 μ in diam.

*CRIBRARIA INTRICATA Schrad. BC.

The cup is present in all collections except one, where it is replaced by costae. The costate sporangia have a more ferruginous aspect than is generally encountered. Spores of the cupulate forms are 5 μ in diam., a smaller size than is generally reported.

*CRIBRARIA PIRIFORMIS Schrad. Chir.

On the slopes of El Volcan at 7000 ft., about 2800 ft. above Boquete, Panamá. This is a mountainous area, which is the normal habitat for *C. piriformis* in the temperate regions. The stipe is unusually long, up to 3 mm, and the dictydine granules of the cup are larger, 1–3.2 μ in diam., than usual. However, these granules found in the thickened, convex nodes are of the usual size.

DICTYDIUM CANCELLATUM (Batsch) Macbr. BC., Chir., *Cart.

*ARCYRIA MAGNA Rex. Chir.

The capillitium seems to grade almost into that of *Arcyria Oerstedii* Rost. The cogs are more or less ill-defined and could easily be confused with spines, but the slightly roughened spores and funnel-shaped calyculus places this specimen with *A. magna*.

ARCYRIA CINEREA (Bull.) Pers. BC., Chir., CZ., *Pun.
ARCYRIA INSIGNIS Kalchbr. & Cke. *BC., CZ.
ARCYRIA DENUDATA (L.) Wettst. BC., Chir., Co., CZ., *Lim., *SJ.
TRICHIA AFFINIS deBary. *BC., Chir., Co., CZ.
HEMITRICHIA STIPITATA (Massee) Macbr. BC., Chir., Co., CZ., *Pun., *Lim., *SJ., *Cart.

This species is very common in Panamá and seems to be common in Costa Rica.

DIACHEA RADIATA Lister & Petch. *BC., CZ.
STEMONITIS NIGRESCENS Rex. *BC., Chir.
*STEMONITIS FUSCA Roth. BC., Chir., CZ.

This very abundant species was collected by Martin in 1936 from the Canal Zone but was not reported by him. We made numerous collections on Barro Colorado Island and in Chiriquí on the slopes of El Volcan. The spores are slightly smaller, 6.4 μ, than is usually reported.

STEMONITIS SPLENDENS Rost. Chir., *Pan., *CZ.
*STEMONITIS WEBBERI Rex. Chir.
STEMONITIS AXIFERA (Bull.) Macbr. *BC., Chir., CZ.
STEMONITIS SMITHII Macbr. *BC., Co.
*COMATRICHA AEQUALIS Peck. Pun.
*COMATRICHA PULCHELLA (C. Bab.) Rost. BC.

We found one collection of this beautiful species fruiting on a living sedge on Barro Colorado Island.

*COMATRICHA TYPHOIDES (Bull.) Rost. BC., CZ., Pun.

C. W. Dodge and Martin both collected this species but it has not been reported by them. We made additional collections on Barro Colorado Island and in Costa Rica.

FULIGO SEPTICA (L.) Weber. BC., Chir., CZ., *Pun., *Her.
*BADHAMIA DECIPIENS (Curt.) Berk. Her.
*PHYSARUM ECHINOSPORUM List. Chir. (FIGS. 6, 7, 8)

This is the first report of this species from Panamá and the second report for the Americas—the first being the type collection. We found it on the slopes of El Volcan above Boquete, Panamá, at 7000 ft. Lister illustrates *P. echinosporum* (*pl. 53*) as having the outer wall of lime as in some Didermas and reports the spores as 8 μ in diam. In our col-

lection the plasmodiocarps and sporangia are dark purple-brown. This color is caused by the inner membranous, iridescent, purple-brown wall. Where the outer wall breaks away from the inner one, it appears hyaline and filled with many rounded lime granules. Spores of our specimen are 11–14 μ in diam. which agrees closely with the size reported by Boedijn (2) from the East Indies.

PHYSARUM BOGORIENSE Racib. *BC., Chir., CZ.

Several collections were made on Barro Colorado Island, one of which is noteworthy. It was fruiting on the underside of a dead stem and the sporangia and short plasmodiocarps were stipitate and pendent. The stipes were black and well-defined.

*PHYSARUM PENETRALE Peck. BC.
*PHYSARUM DIDERMOIDES (Pers.) Rost. Ala.
PHYSARUM TENEREUM Rex. *BC., Chir., CZ., *Pun.

A collection was made at the Esquinas Forest Reserve outside of Palmar Sur, Costa Rica.

PHYSARUM COMPRESSUM Alb. & Schw. *BC., Chir.
PHYSARUM NUTANS Pers. *BC., Chir.
*DIDERMA CHONDRIODERMA (deB. & Rost.) G. Lister. Guan.
*DIDYMIUM CLAVUS (Alb. & Schw.) Rab. Pun., above Palmar Norte.
DIDYMIUM SQUAMULOSUM (Alb. & Schw.) Fr. BC., Chir., CZ., *SJ.
***Didymium verrucosporum** sp. nov. (FIGS. 4, 5), CZ.

Sporangiis stipitatis, globosis, umbilicatis, nutanibus, 0.9–1 mm diam., altudine ca. 1 mm; peridiis cum albis crystallis calcareis; stipitibus superne tenuioribus et pallescentibus; hypothallis membranceis, fusco-purpureis, parvis; capillitiis fusco-violaceis, ramosis, tumidis et acuminibus pallidis; columella globosa, alba; sporis globosis, fusco-violaceis ad lucem transmissam, verrucis crassis et distinctis, aliquantibus in coronis vel dorsis, 7–10 μ diam. Plasmodio ignoto.

Typus: GWM & ALW *7545* (SUI Herbarium).
Locus typic.: Río Sardinilla, Canal Zone, Panamá.
Habitat: In foliis mortuis.
Distributio: Locus typic. solum.

Sporangia stipitate, globose, umbilicate below, nodding, 0.9–1 mm diam., ca. 1 mm tall; peridium covered with scattered white stellate lime crystals; stipe dark, tapering upwards and paler toward apex; hypothallus membranaceous, purple-brown, inconspicuous; capillitium violaceous-brown, branching, occasionally with swollen nodes, tips pale; columella globose, white, ½ or less the height of the sporangium; spores globose,

dark purple in mass, violaceous-brown by transmitted light, coarsely and distinctly warted, often the warts in groups and sometimes forming ridges, 7–10 μ diam. Plasmodium unknown.

D. verrucosporum is closely related to *Didymium nigripes* (Link) Fr. and to *Didymium Iridis* (Ditmar) Fr. It differs from the former in its white, globose columella, opaque stalk, purplish-brown capillitium and the curiously ornamented spores. *D. Iridis* is probably more closely related but the spores of *D. verrucosporum* are distinct from those of *D. Iridis*. The closely warted spores, darker stipe and darker capillitium are believed enough to justify the establishment of a new species.

The number of species reported by Martin, Standley and Weston totalled 75. To that number 13 more species, reported here for the first time, should be added, bringing the total number of Myxomycetes known from Panamá to 88. Two of these species are new. Fifteen species, previously unreported from Costa Rica, are also listed, seven of these being unreported from either Panamá or Costa Rica.

Grateful acknowledgment is due to Mr. James Zetek of the Canal Zone Biological Area; Mr. & Mrs. A. M. Mönniche, owners of Finca Lérida, for the use of Casita Alta, a small house on the slopes of El Volcan above Boquete, Panamá; Mr. & Mrs. Paul Allen of Palmar Sur, Costa Rica and the officials of the United Fruit Company for the many courtesies extended during our stay.

This work was done in the Mycological Laboratory of the State University of Iowa under the supervision of Professor G. W. Martin. The collecting was made possible by a research grant from the National Science Foundation.

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A NEW SPECIES OF PLATYGLOEA FROM LOUISIANA

BERNARD LOWY

(WITH 14 FIGURES)

Platygloea longibasidia sp. nov. (FIGS. 1–14)

Fructificatio pustulata, 3–6 mm diam., humida ceracea alba, gelatinosa, sicca cornea, conspicua, late effusa, grisea alba; hyphae enodosae, 3–4.5 μ diam., raro septata; paraphyses longae, cylindraceae, 2–3.5 μ diam., emergentiae; probasidia clavata; basidia cylindracea, aseptata vel transversa 4-septata, (38–)52–78(–135) $\mu \times$ 5.5–9.6 μ; basidiosporae oblongae cylindraceae vel allantoideae, apiculatae, hyalinae, (12.5–)16.5–25.5(–31) $\mu \times$ (5.5–)6–7.5(–8) μ; per repetitionem germinantes vel promycelium promittentes.

Fructification gelatinous throughout, up to 6 mm broad, waxy-white when wet, pustulate at first, becoming confluent and finally broadly effused; drying to a whitish or greyish-white conspicuous horny film; hyphae 3–4.5 μ in diameter, without clamp connections, sparsely septate; paraphyses narrowly cylindrical, 2–3.5 μ in diameter, some emergent, extending beyond surface of fructification 55–100 μ or more, others terminating near distal end of basidia; probasidia clavate, developing directly into cylindrical basidia, non-septate to 4-septate, (38–)52–78 (–135) $\mu \times$ 5.5–9.6 μ; basidiospores 1-celled, hyaline, oblong-cylindrical to allantoid, apiculate, (12.5–)16.5–25.5(–31) $\mu \times$ (5.5–)6–7.5(–8) μ; germinating by germ tube or by repetition.

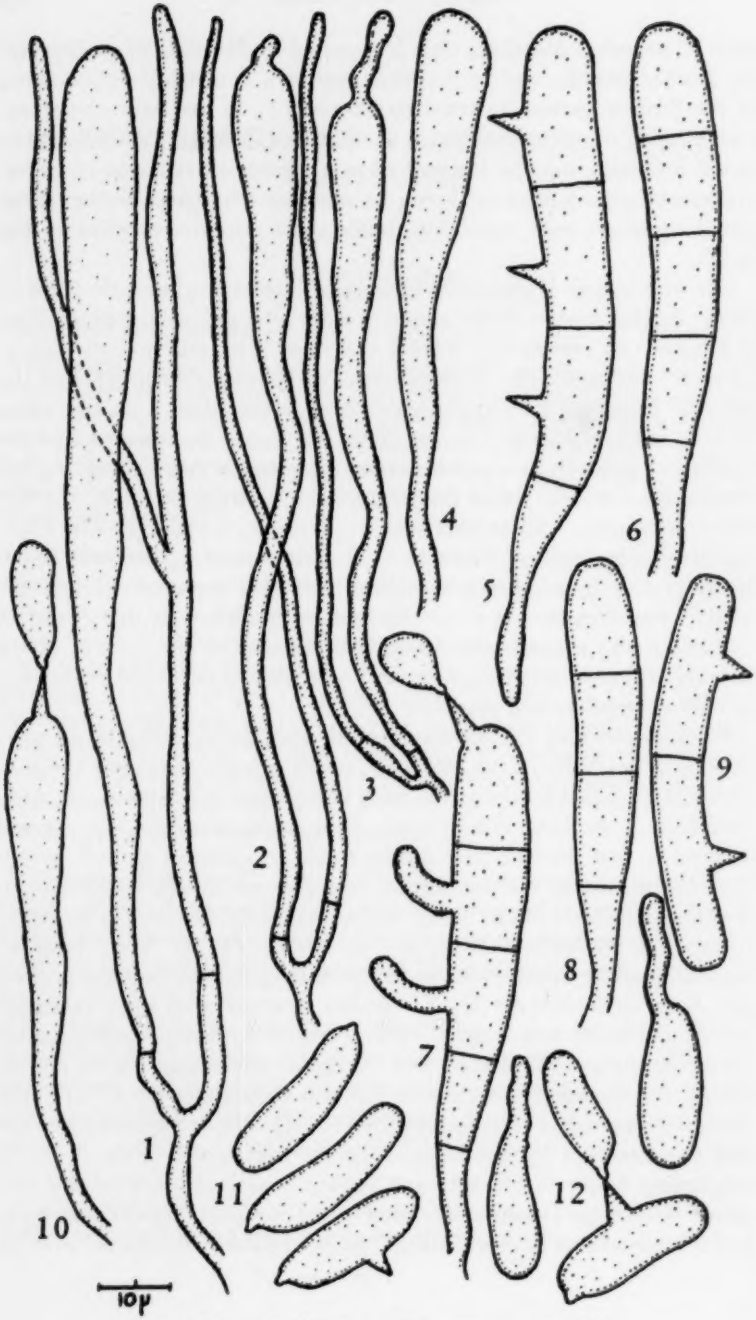
Louisiana. Goodwood. On dead, partly decorticated frondose wood, April 7, 1953. B. Lowy *8250*, TYPE. Growing in association with a species of *Graphium* and a moss, *Leptodictyium* sp., both of which were overgrown in places by the *Platygloea*. No evidence of parasitism was noted.

The genus *Platygloea* may be characterized by its resupinate habit, gelatinous or waxy texture, cylindrical basidia, persistence or absence of hypobasidium and its usually saprobic nature. Basidia may be 1–4-septate, considerable variation occurring within individual species. For example, *P. unispora* Olive is described by Olive (**4**) as 1–3-septate, producing a single terminal basidiospore. *P. vestita* B. & G., according to Bourdot and Galzin (**1**), has basidia which are 1–3-septate, all cells of which are capable of producing epibasidia and bearing basidiospores,

while *P. pustulata* Martin & Cain is reported by Martin (2) as developing 2-celled basidia, each cell giving rise to a cylindrical epibasidium. Of the thirteen genera included by Martin (3) in the Auriculariaceae, *Platygloea* is the most variable in basidial morphology. Since morphological instability may be interpreted as a significant criterion of primitiveness, it is not unreasonable to conclude that *Platygloea*, to the extent that it manifests such variability, is the most primitive member of the family.

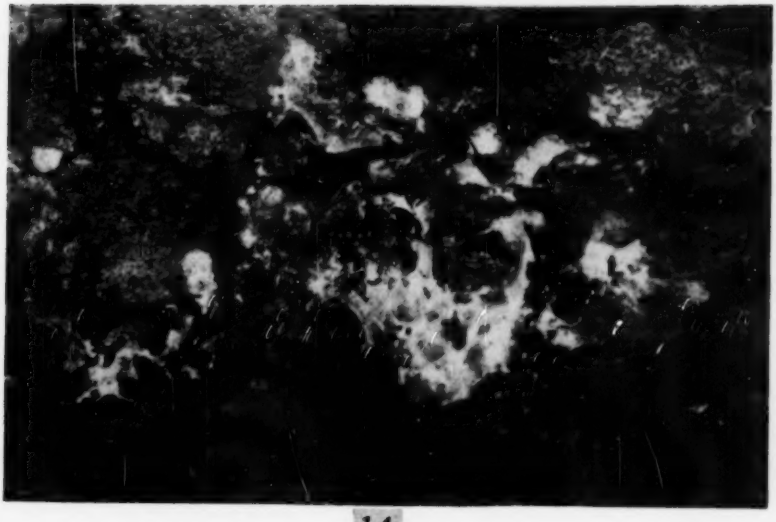
The new fungus is especially interesting from a phylogenetic point of view. In the opinion of the writer, it cannot be seriously doubted that, as Rogers (6) and others believe, the rusts have arisen from auriculariaceous ancestors, and, more specifically, the idea is defensible that the ancestral type was a *Platygloea*-like form, rather than a strictly parasitic one such as *Jola* or *Eocronartium*. If it may be assumed that the Uredinales arose from saprobic forms, the position taken regarding the possible ancestral nature of the new species is strengthened by the fact that it is saprobic. In another respect, however, it appears to be intermediate in the basidial hierarchy. No evidence of a persistent hypobasidium was found, the probasidium becoming transformed into the epibasidium directly. It is on the basis of variation in this character that Olive (5) suggests the need for a revision of our concept of the genus, which now includes species with and without persistent probasidia, as well as parasites and saprobes.

The most striking characteristic of the new species is the broad morphological flexibility of the basidium, which extends the entire range of variation described for the genus, from non-septate to 4-septate. A notable feature is the large size of some of the probasidia (FIG. 1). It was believed at first that the new species might be identical with *P. vestita* B. & G. because of the presence of emergent structures referred to by Bourdot and Galzin (1) as "longs filaments dressés, flexueux et toruleux" (measuring 60–100 × 6–10 μ) and by Martin (3) as "erect branches resembling gleocystidia, flexuous and with irregular thickenings, projecting above the surface 40–50 μ." Similar structure with some variations were noted in the new fungus. The emergent hyphae projected further above the surface (55–100 μ) and "irregular thickenings" were not observed, the filaments being almost uniform throughout (2–3.5 μ). Examination of crushed preparations from freshly collected material revealed that the emergent hyphae were elongated paraphyses (FIGS. 1, 2, 3), originating below the basidia and having homogeneous, granular contents. Under the binocular, the prominent, emergent dikaryo-paraphyses had the appearance of erect, delicate hairs, regularly distributed over the



FIGS. 1–12. (Explanation of Figures on page 104.)

13



14

FIGS. 13–14. 13. *Platygloea longibasidia* in fresh condition, × 2. Type. 14. Dried specimen of *Platygloea longibasidia*, × 3. Type.

smooth surface of the fructification. When the fungus was moistened for reexamination after it had been dried, the emergent dikaryo-paraphyses were no longer evident. Some probasidia were observed to give rise to sterile, tortuous, narrowly cylindrical structures of varying length, up to 80 × 3.5 μ in diameter, which were not seen in fresh material but were found in preparations kept in a moist chamber for several days.

Through the courtesy of Dr. G. W. Martin, I have been able to examine a specimen of *P. vestita*. It is clearly distinct from the new fungus in some of the ways already described. In addition, the gross appearance of the two species differs greatly. *P. vestita*, as Martin (**3**) indicates, "becomes almost invisible when dry," whereas the new species dries to a conspicuous horny crust (FIG. 14).

The type is deposited in the mycological herbarium of Louisiana State University. Portions of the type have been deposited in the herbaria of the State University of Iowa, Iowa City, and of the New York Botanical Garden.

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EXPLANATION OF FIGS. 1–12

FIGS. 1–12. 1. Probasidium with branched paraphysis. 2, 3. Probasidia with sterile, terminal structures. 4. Probasidium. 5. 4-celled basidium with 3 sterigmata. 6. Immature 4-celled basidium. 7. Germinating basidium. 8. Immature 3-celled basidium. 9. Mature 2-celled basidium. 10. Mature 1-celled basidium producing single, terminal basidiospore. 11. Three basidiospores, one producing a secondary epibasidium. 12. Group of basidiospores; two germinating by germ tube, one by repetition.

TAXONOMIC DIFFERENTIATION BETWEEN ASCOBOLUS STERCORARIUS AND A. FURFURACEUS

LINDSAY S. OLIVE

(WITH 4 FIGURES)

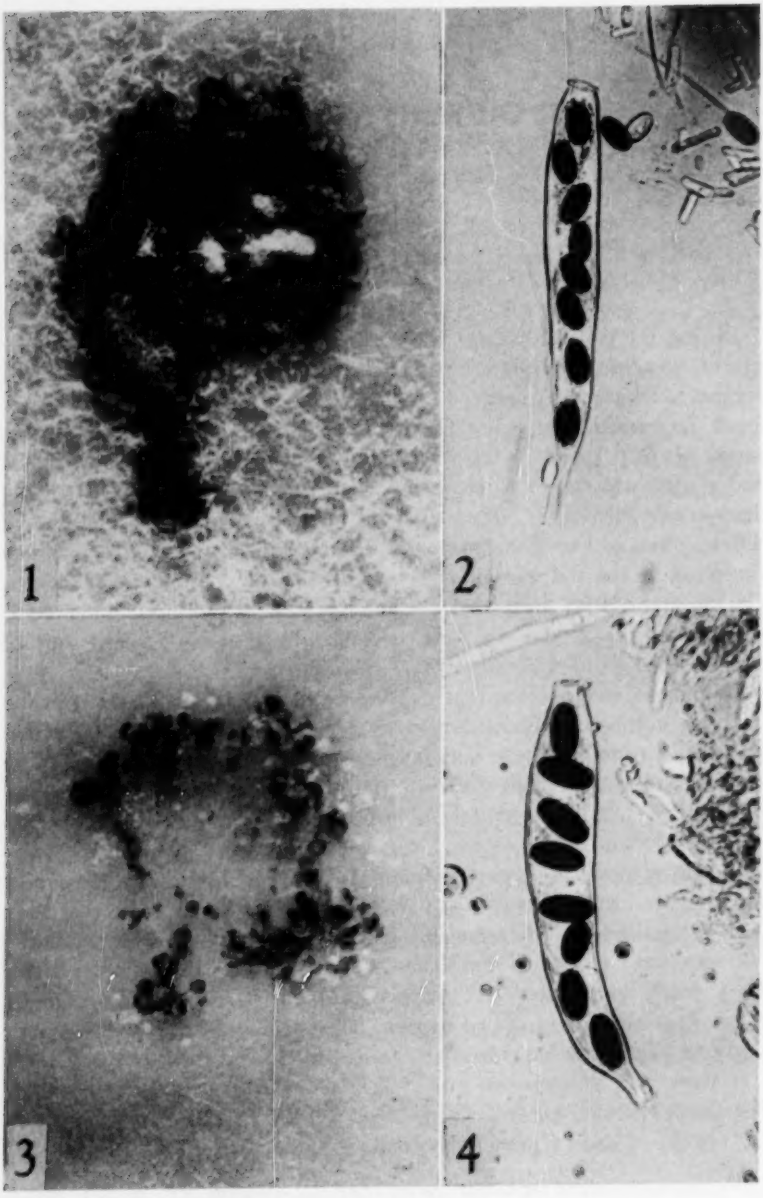
During the course of recent studies on the life cycles of certain species of Ascoboleae in our laboratory, a number of cultures isolated from apothecia which had appeared on cow and buffalo dung from the New York Zoological Park were tentatively identified as *Ascobolus stercorarius* (Bull.) Schröt., a heterothallic discomycete with yellow apothecia and purple ascospores. However, Mr. George Bistis, graduate student in our laboratory, in an attempt to cross single-spore cultures of different sets of isolates from separate collections, found that certain sets could not be crossed with other sets in any of the possible combinations. On the other hand, fertile apothecia were readily produced when compatible cultures of each set were crossed. In all cases a single pair of allelomorphs was found to control compatibility.

It soon became obvious that in spite of many similarities between the different cultures, two distinct species were involved. The distinctive features were recognizable both on dung and on artificial media, and the most significant of these involved the general appearance of the apothecium, size and striation of the ascospores, nature of the paraphyses, and oidial production.

Recourse to the literature indicates that the two species are *Ascobolus stercorarius* (Bull.) Schröt. and *A. furfuraceus* Pers. These two have been recognized by only a few investigators as distinct species, while the majority have treated *A. furfuraceus* as a synonym of *A. stercorarius*. As a result, most taxonomic treatments of *A. stercorarius* are actually composite descriptions of two species. The distinguishing characteristics of the two fungi are listed below.

ASCOBOLUS STERCORARIUS (Bull.) Schröt. Krypt.-Fl. Schles. 3^2: 56. 1893. Quoad typum non quoad descriptionem. (FIGS. 1, 2)

Peziza stercoraria Bull. var. *lutea* (var. 1). Champ. Fr., *pl. 376, fig. 1.* 1787.



FIGS. 1–4.

Ascobolus furfuraceus Pers. var. *flavo-virens* (var. β). Myc. Eur. **1**: 340. 1822.

Apothecia scattered or gregarious, 0.5–5 mm in diameter, sessile, at first subglobose, without poroid opening above, expanding to saucer-shaped and finally convex, hymenium and exterior yellow, nearly smooth except for the margin which may be somewhat pruinose; asci clavate, 14–24 × 120–235 μ, 8-spored, ascospores uniseriate, biseriate, or irregularly disposed, 9.5–12.5 × 16.6–21.6 μ, spore wall thick, at first hyaline, becoming purple and finally brown, sculptured with relatively course striae which frequently anastomose, about 5 to 7 striae visible across one side of spore; paraphyses slender, typically enlarged apically or sub-apically, embedded in a golden yellow mucilaginous layer. Oidia produced in long chains on the vegetative hyphae, mostly 3.4–4.7 μ in width.

ASCOBOLUS FURFURACEUS Pers. Myc. Eur. **1**: 340. 1822. (FIGS. 3, 4)

Peziza stercoraria Bull. var. *violacea* (var. 2). Champ. Fr., *pl. 438, fig. 4.* 1789.

Ascobolus furfuraceus Pers. var. *fuscus* (var. α). Myc. Eur. **1**: 340. 1822.

Apothecia scattered or gregarious, 0.5–5 mm in diameter, sessile, at first subglobose and with poroid aperture above, expanding to become saucer-shaped, finally convex in age, hymenium bright yellow, exterior distinctly furfuraceous; asci clavate, 18–35 × 120–335 μ, 8-spored, ascospores uniseriate, biseriate, or irregularly disposed, 10.5–13.3 × 21.6–28.2 μ, spore wall thick, at first hyaline, then becoming purple and finally brown, sculptured with relatively delicate striae which occasionally anastomose, about 8 or 9 striae visible on one side of spore; paraphyses slender, not enlarged above, embedded in a golden yellow mucilaginous layer. Oidia produced in chains on the vegetative hyphae, mostly 3.7–5.9 μ in width, oidial hyphae frequently in clusters.

On the yeast extract-filter paper media recommended by Wood (**1953**) and by Yu (**1953**) the two species may be readily distinguished. Both produce numerous, usually small, fertile apothecia in artificial culture. In *A. stercorarius* there is a fluffy white growth consisting of hyphae and large quantities of oidia, which often partially obscure the apothecia. In *A. furfuraceus* this fluffy type of growth is less apparent or sometimes

FIGS. 1, 2. *Ascobolus stercorarius.* 1. Mature apothecia on yeast-filter paper agar. Note fluffy vegetative growth of mycelium. × 1.7. 2. Ascus of *A. stercorarius.* Note also the oidia nearby. × 294. FIGS. 3, 4. *Ascobolus furfuraceus.* 3. Mature apothecia on yeast-filter paper agar. × 1.7. 4. Ascus. × 294.

nearly lacking, and oidia are frequently less abundant. On sterilized cow dung, *A. stercorarius* produced the characteristic fluffy white growth with abundant oidia, while *A. furfuraceus* formed its oidia in conspicuous clusters. Few apothecia developed in the latter case, however. It is interesting to note that, in nature, the vegetative growth of these fungi is generally not noticeable. This is probably due to the restrictive effects of antagonistic or competing organisms naturally present in the substrate.

Bulliard and Persoon apparently considered these two fungi as varieties of the same species. Although it is difficult to be entirely certain that the two "varieties," which were rather fragmentarily described by these investigators, are identical with our two fungi, there are several indications that this is the case. Bulliard's descriptions and illustrations point out the fact that the apothecia of his variety *lutea* (*A. stercorarius*) are not distinctly furfuraceous externally, and are more turbinate than the apothecia of the variety *violacea* (*A. furfuraceus*), which are more flattened and saucer-shaped as well as mealy in appearance externally. These differences have also been consistently noted in our two fungi. It is impossible to ascertain from Persoon's brief descriptions any important differences in the two varieties which he included under the name of *A. furfuraceus*. However, Persoon did include Bulliard's variety *violacea* as a synonym of his variety *fuscus* and Bulliard's variety *lutea* as a synonym of his variety *flavo-virens*. Since the variety *fuscus* is the first (var. α) of the two varieties treated in Persoon's description, it must be considered typical of the species *A. furfuraceus* Pers., and Bulliard's variety *violacea* becomes a synonym of that species.

Bulliard's *Peziza stercoraria* var. *lutea* (var. 1) obviously must be accepted as the type of the species, *Ascobolus stercorarius* (Bull.) Schröt. In making the transfer of this fungus to *Ascobolus*, Schröter also included *A. furfuraceus* Pers. as a synonym. Furthermore, it is apparent that Schröter's description primarily characterizes Bulliard's second variety, *violacea*, which we have found to be synonymous with *A. furfuraceus*. The writer has been informed by Dr. D. P. Rogers that, in accordance with the accepted rules of nomenclature, Schröter's combination must be retained, while the description is emended to fit Bulliard's concept of the variety *violacea*, which remains as the type of the species.

There has been much confusion in the literature concerning these two species, and it is frequently impossible to determine from the various publications which one of the two was being considered, or whether both were included in the same description. Fraser (Gwynne-Vaughan) and Brooks (**1909**) investigated the cytology of an *Ascobolus* which they

called *A. furfuraceus,* but the fungus was not described and the present writer is unable to determine which species was involved. Gwynne-Vaughan and Barnes (**1937**) later treated *A. furfuraceus* as a synonym of *A. stercorarius.* It is clear from the descriptions by Green (**1931**) and Dowding (**1931**) of a fungus which they called *A. stercorarius,* that these two investigators had what we consider typical material of *A. stercorarius* (Bull.) Schröt. The description of *A. stercorarius* by Seaver (**1942**) is a composite one and undoubtedly includes the characteristics of both species, as did Schröter's description earlier.

A. glaber Pers., another species which produces oidia, is more likely to be confused with *A. stercorarius* than with *A. furfuraceus,* but its apothecia are said to be appreciably smaller (0.5–1 mm in diameter). We have not collected this species.

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NOTES AND BRIEF ARTICLES

Herbarium Specimens of Dermatophytes

Medical mycology is well served by special techniques. Many of these are the rediscoveries or adaptations by medical men of well known mycological methods and it is with diffidence that the attention of medical mycologists is drawn to the usefulness of yet another familiar mycological procedure.

A systematist who turns to a study of fungi of medical importance feels handicapped by the lack of specimens authenticated by earlier workers and he is impressed by the absence of material of these forms in herbaria which contain such an ample record of fungi pathogenic for plants and for insects. Some fungi, including some of those pathogenic for man, do not make satisfactory herbarium specimens. Others, including the dermatophytes, yield specimens of permanent value and yet it is rare to find even a packet of *Microsporum*-infected hairs in any of the large national herbaria. Hitherto students of the dermatophytes have generally limited their provision for posterity to depositing cultures in one or more culture collections. Apart from the usual hazards of such collections, most cultures of dermatophytes sooner or later become pleomorphic (and so virtually useless) when a carefully preserved specimen would often provide a valuable clue to the original appearance of the isolate and allow a published description to be checked or an inadequate diagnosis to be emended.

It is the current practice at the Commonwealth Mycological Institute, Kew, to treat the culture collection as an integral part of the herbarium and a dried culture of every accession to the culture collection is deposited in the herbarium. It is suggested that this procedure might be more widely adopted, not only by taxonomists but also by those undertaking experimental studies on pathogenic fungi.

What constitutes an adequate specimen depends on the circumstances and is in part a matter of opportunity. The type specimen of any new dermatophyte should comprise 1) infected hairs or skin scales and 2) a dried culture on a medium favourable for the development of spores and other diagnostic structures and this should, if possible, be a "primary" culture, i.e. one derived from an inoculum of infected material. These may be supplemented by a permanent microscopical preparation (such

as a lactophenol mount sealed with nail lacquer; see R. W. Riddell, Mycologia **42**: 267–270, 1950), drawing, colour transparency, etc. For a culture used in experimental work similar evidence is desirable.

The detailed procedure for preparing a dried culture will vary from one worker to another. A method of proved usefulness is to grow the dermatophyte in a Petri dish containing a 5 mm layer of suitable medium for 7–14 days or longer. A piece of filter paper soaked in formalin is then placed in the lid of the dish for 24 hours or so after which the killed culture is cut out of the plate with a scalpel, transferred to a sheet of cellophane stretched over a piece of stout cardboard or thin plywood, and put overnight in an incubator at 37° C. This is usually long enough to dry the agar to a thin film which adheres to the cellophane. The cellophane is then removed from the card and folded over so as to form a transparent envelope which is then placed together with any sample of infected material, in a herbarium packet on which the appropriate details are recorded. The only subsequent precautions are to ensure that the material is kept dry and free from the depredations of insects. Dried cultures prepared in this way seem to be reasonably permanent and often retain characteristic pigmentation. When subsequently examined by the aid of a binocular microscope or by removing fragments with a needle and mounting in lactophenol, macroconidia and other structures are usually found to be well preserved.

Major H. A. Dade of the Commonwealth Mycological Institute, with whom this note was discussed, told me that in that institute it is customary to pin down the culture-bearing strip of agar, until dry, on a layer of glue on the bottom of one of the special cardboard containers for microscope slides in routine use in Herb. I.M.I. This has the advantage of protecting delicate conidiophores from injury due to pressure or rubbing. He also recalled that mycological herbaria are organized and maintained by botanists and suggested that the reluctance of such curators to handle human pathogens would be overcome by the knowledge that any infected hairs or skin scales offered to them had, like the dried cultures, been rendered inocuous by fumigation with formaline or propylene dioxide.

Although especially advocated for dermatophytes and other "moulds" the method also yields informative specimens of mycelial yeasts such as species of *Candida*.—G. C. AINSWORTH, University College of the South West of England, Exeter, Devon.

Agaricus Blockii sp. nov.

Pileo conico-convexo, 4.5–7 cm lato, albo, squamuloso, grato; lamellis angustatis, 3–5 mm latis; sporis ellipsoideis, $5 \times 4\,\mu$; stipite albo, 5×1–1.5 cm, supra glabro, infra squamuloso; annulo parvo, albo.

Pileus conic to truncate-convex, gregarious, 4.5–7 cm broad; surface white with small white fibrillose scales, disk isabelline and scaly, margin undulate, white, not projecting; context white, unchanging, 6 mm thick, nutty, not amygdaline; lamellae just free, tapering at both ends, crowded, narrow, 3–5 mm, white, bright-pink when wounded, blackish at maturity; spores broadly ellipsoid, smooth, about $5 \times 4\,\mu$; stipe solid, white, about 5×1–1.5 cm, apex smooth and glabrous, below the annulus obese, with conspicuous tawny fibrillose scales pointed upward, reddish-brown when bruised; annulus median, narrow, white, unchanging.

Type collected by Dr. S. S. Block on a rich open lawn in Gainesville, Fla., July 6, 1950 (*F 21533*). Rare in the vicinity. The scales on the stipe resemble those on *Psalliota perrara* Schulz., as figured by Bresadola (Icon. Myc. Tab. 832).—W. A. MURRILL.

REPORT OF THE 1952 FORAY

The 1952 Foray of the Mycological Society of America was held at Ithaca, New York, on September 4, 5, and 6. Favorable weather preceding the Foray had resulted in an abundance of fungi, especially fleshy forms, and the collecting was very good.

The first excursion, on the morning of Sept. 4, was to Coy Glen, followed by an afternoon trip to Michigan Hollow, near Danby. The whole of Friday, Sept. 5 was spent at the Lloyd-Cornell Preserve at McLean. The Lloyd-Cornell Preserve at Ringwood was visited on Saturday forenoon and the Lloyd-Cornell Preserve near Slaterville in the afternoon.

The weather during the Foray was ideal and contributed much to the pleasure of the excursions. As many as 80 participants were present on some of the trips and 67 Society members and guests were on hand for the group photograph taken Saturday afternoon in front of Cornell University's Plant Science Building.

Excellent facilities for care, study, and identification of fungi collected were provided in the Mycological Laboratory of the Department of Plant Pathology. The excursions were well planned and well guided, the local committee being augmented by a number of Cornell graduate students who were familiar with the areas visited.

The committee in charge, consisting of Dr. Richard P. Korf, Chairman, Mr. M. A. Rosinski, and Dr. Charles D. Chupp, is much to be congratulated and the Society is very grateful to them.

On Sunday following the Foray members of the Society and guests were entertained at a picnic at "Mycolodge," hosts being Dr. Korf and his parents.

The fungi which were collected and reported are listed below, followed by a symbol representing the collector and/or the place of deposit of the specimen. In many cases, duplicate specimens have been deposited in the Department of Plant Pathology Herbarium at Cornell University. The correspondence regarding the collections is deposited in that herbarium under the accession number CUP 43327.[1] The assistance of Miss E. K. Cash, Drs. W. B. Cooke, C. W. Dodge, S. J. Hughes, G. W. Martin, D. P. Rogers, C. T. Rogerson, and Messrs. M. A. Rosinski and R. L. Shaffer, who have checked references and citations, is gratefully acknowledged by Dr. R. P. Korf, who assembled the list. Names of genera and species in brackets are more common names or names under which the specimens are deposited. The symbols used are:

(A) = S. J. Smith, New York State Museum, Albany.

(B) = E. A. Bessey, Michigan State College.

(C) = C. W. Boothroyd, M. Corbett, W. C. Denison, Judith Diamant, R. P. Korf, M. A. Rosinski, and R. L. Shaffer, Cornell University.

(D) = E. G. Simmons, Dartmouth College.

(E) = W. B. and Vivian G. Cooke, Environmental Health Center, Cincinnati, Ohio.

(F) = Mrs. A. J. Mix, University of Kansas.

(G) = Helen M. Gilkey, Oregon State College.

(H) = K. H. Harrison, Laboratory of Plant Pathology, Kentville, Nova Scotia.

(I) = W. I. Illman, Carleton College, Ottawa.

(J) = E. J. Bubieniec and E. A. Stowell, University of Wisconsin.

(K) = C. T. Rogerson, Kansas State College.

(L) = B. Lowy, Louisiana State University.

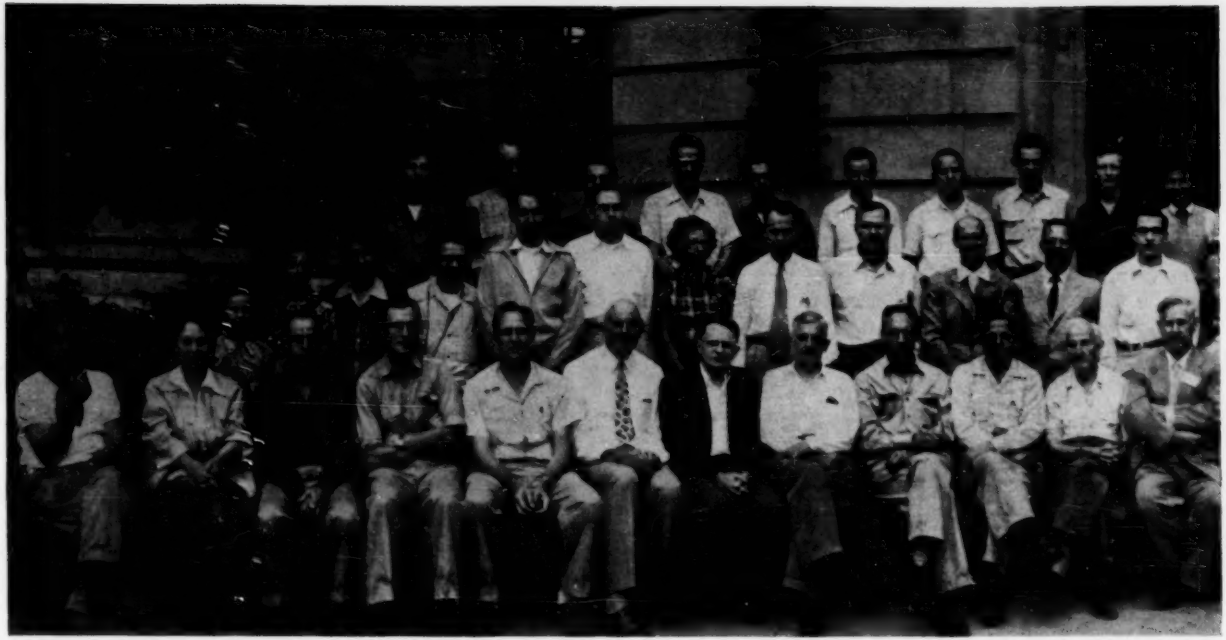
(M) = E. D. Rudolph, Missouri Botanical Garden.

(N) = D. P. Rogers, New York Botanical Garden.

(O) = I. L. Conners, J. W. Groves, Ruth M. Horner, S. J. Hughes, Ruth Macrae, and Mildred K. Nobles, Science Service, Ottawa.

(P) = E. T. Reese, Philadelphia Quartermaster Depot.

[1] Lists of species were received from Dr. R. F. Cain and Miss Ruth Horner too late for inclusion in this report. These lists are filed with the correspondence.



First row: A. J. Mix, Katherine L. Mix, W. W. Ray, V. M. Cutter, Jr., W. H. Bragonier, G. F. Weber, J. A. Stevenson, Wm. W. Diehl, G. W. Martin, J. C. Gilman, E. A. Bessey, C. Thom, Wm. B. Cooke, M. F. Barrus, Laura A. Kolk, C. D. Chupp, Ruth Macrae,* Mildred K. Nobles,* Helen M. Gilkey, C. W. Dodge, J. W. Groves,* I. L. Conners,* D. P. Rogers.

Second Row: Sandra Ray, Barbara Ray, Mrs. W. W. Ray, H. H. Lyon, C. T. Rogerson, J. B. Routien, Lois H. Tiffany, M. D. Whitehead, C. L. Lefebvre, N. H. White,** T. Sproston, E. J. Bubieniec, E. G. Simmons, G. T. Johnson, E. D. Rudolph, M. B. Harrison, M. K. Corbett, C. I. Hannon, Ruth M. Horner,* Margo Denison, Jackie Vestal, Esther A. Dick, S. J. Hughes,* J. A. Browning, R. P. Korf, D. S. Welch.

Third Row: M. A. Rosinski, R. G. Atkinson,* R. L. Shaffer, F. W. Holmes, G. Sowell, Jr., E. A. Stowell, J. R. Keller, Wm. C. Denison, Wm. I. Illman,* E. G. Bassett, W. L. Williams, T. J. Bulat, B. Lowy, G. Silber, J. P. Ross, R. Segall, Muriel O'Brien, Jean Dubé, Vivian G. Cooke.

Also present but bashful: C. W. Boothroyd, R. F. Cain,* D. Connell, G. D. Darker, Jody Diamant, C. H. Driver, K. D. Fezer, K. H. Harrison,* Ursula Hirsch, L. Johnson, Susan Lane, H. Luke, Marguerite L. Monroe, R. T. Moore, A. P. Pieringer, E. T. Reese, Lois Reese, Carol Anne Reese, D. A. Roberts, L. A. Schafer, R. T. Sherwood, S. J. Smith.

* Canada (10): 2 provinces. ** Australia (1). U. S. A. (79): 20 states and D. C.

(Q) = Laura A. Kolk, Brooklyn College.

(R) = Esther A. Dick and Jacqueline Vestal, Brown University.

(S) = G. W. Martin, State University of Iowa.

(T) = R. F. Cain, University of Toronto.

(U) = W. W. Diehl, C. L. Lefebvre, Muriel O'Brien, and J. A. Stevenson, U. S. D. A. Plant Industry Station, Beltsville, Md.

(V) = R. G. Atkinson, Laboratory of Plant Pathology, St. Catharines, Ont.

(W) = M. D. Whitehead, Texas A. & M. College.

MYXOMYCETES: *Amaurochaete fuliginosa* (Sow.) Macbr. (S); *Arcyria cinerea* (Bull.) Pers. (J); *A. denudata* (L.) Wettst. (I, J, U); *A. incarnata* (Pers.) Pers. (S); *A. nutans* (Bull.) Grev. (J, W); *Badhamia decipiens* (M. A. Curt.) Berk. (S); *B. curtisii* (Berk.) Rost. [*B. rubiginosa*] (J, U); *Ceratiomyxa fruticulosa* (Müll.) Macbr. (O); *Comatrichia typhoides* (Bull.) Rost. (J); *Diderma montanum* (Meylan) Meylan (S); *Didymium iridis* (Ditm.) Fr. [*D. xanthopus*] (S), on *Sphagnum* (I); *D. melanospermum* (Pers.) Macbr. (sessile phase) (S); *Enerthenema papillatum* (Pers.) Rost. (S); *Enteridium rozeanum* (Rost.) Wing. (S); *Fuligo muscorum* A. & S. (S); *F. septica* (L.) Weber (J, S, U); *Hemitrichia chrysospora* Lister (U); *H. serpula* (Scop.) Rost. (U); *H. stipitata* (Massee) Macbr. (J, S); *H. vesparium* (Batsch) Macbr. (J); *Leocarpus fragilis* (Dicks.) Rost. (Q, S); *Licea minima* Fr. (S); *Perichaena chrysosperma* (Currey) Lister (S); *Physarum globuliferum* (Bull.) Pers. (J, S); *P. pusillum* (B. & C.) G. Lister (U); *P. tenerum* Rex (S); *P. viride* (Bull.) Pers. (J); *P.* sp. (J); *Stemonitis axifera* (Bull.) Macbr. (S); *S. fusca* Roth (S), on *Acer* (U); *Trichia botrytis* (Gmel.) Pers. (S); *T. favoginea* (Batsch) Pers. (S); *T. persimilis* Karst. (S); *T. scabra* Rost. (S); *T. subfusca* Rex (S); *T. varia* (Pers.) Pers. (O, Q, S); *T. verrucosa* Berk. (U).

PHYCOMYCETES: *Albugo bliti* (Biv.-Bern.) Kuntze on *Amaranthus* (I), on *A. retroflexus* (U); *Endogone pisiformis* Lk. ex Fr. [*E. sphagnophila*] (I), on *Sphagnum* (A, K, N); *E.* sp. (L); *Mortierella* sp. (I); *Pilobolus crystallinus* Tode ex Fr. (N); *P.* sp. (I); *Synchytrium aecidioides* (Pk.) Lagerh. on *Amphicarpa bracteata* (I); *Syzygites megalocarpus* Ehrh. ex Fr. [*Sporodinia grandis*] on *Boletus americanus* (O), on *Lactarius* (I, K).

ASCOMYCETES (except Discomycetes): *Bombardia fasciculata* Fr. on *Tilia* (I); *Botryosphaeria ribis* (Tode ex Fr.) Grossenb. & Dug. on *Fagus* (U); *Cordyceps ophioglossoides* (Ehrh. ex Fr.) Lk. on *Elaphomyces* (K), on *E. muricatus* (N); *Daldinia concentrica* (Bolt. ex Fr.) Ces. & de Not. (J, U); *Diatrype stigma* (Hoff. ex Fr.) Fr. on *Fagus* (U); *Dibotryon morbosum* (Schw.) Th. & Syd. (E, W); *Elaphomyces muricatus* Fr. (N); *Epipeltis* [*Schizothyrium*] *gaultheriae* (Curt. ex E. & E.) Theiss. on *Gaultheria procumbens* (B); *Erysiphe polygoni* DC. ex Mérat on *Ranunculus abortivus* (P), (stat. conid.) on *Clematis virginiana* (B); *Glonium clavisporum* Seaver (stat. conid.) (O); *G. stellatum* Muhl. ex Fr. (C), on *Acer* (U); *Herpotrichia* [*Lasiosphaeria*] *pezizula* (B. & C.) Wint. (K, O); *Hypocrea gelatinosa* (Tode ex Fr.) Fr. (J, K, P), on *Betula* (U); *H. rufa* (Pers. ex Fr.) Fr. (K, U); *Hypomyces armeniacus* Tul. (K, P); *H. aurantius* (Pers. ex Fr.) Tul. (K), on *Daedalea unicolor* (E); *H.* [*Apiocrea*] *chrysospermus* Tul. on *Boletus* (E, K), (stat. conid.: *Sepedonium chrysospermum* Bull. ex Fr.) (I, O P),

on *Russula* (?) (E); *H. hyalinus* (Schw. ex Fr.) Tul. (K, P); *H. lactifluorum* (Schw. ex Fr.) Tul. (E, W), on *Lactarius* (K); *H. lateritius* (Fr.) Tul. on *Lactarius* (K); *H. porotheliiformis* Lindtner on *Ganoderma applanatum* (C, K); *H. rosellus* (A. & S. ex Fr.) Tul. (K), on *Polyporus* (P); *Hypoxylon cohaerens* (Pers. ex Fr.) Fr. (W), on *Fagus* (I, J, N, U); *H. rubiginosum* (Pers. ex Fr.) Fr. (U); *Hysterium pulicare* Pers. ex Fr. (L); *Hysterographium cinerascens* (Schw.) E. & E. (L); *H. mori* (Schw.) Rehm (O); *H.* sp. on *Acer saccharum* (B); *Lasiosphaeria hirsuta* (Fr.) Ces. & de Not. (I, O); *L. hispida* (Tode ex Fr.) Fuckel (K); *L. ovina* (Pers. ex Fr.) Ces. & de Not. (I, O); *L. viridicoma* (Clint. & Pk.) Sacc. (O); *Microsphaera penicillata* (Wallr. ex Fr.) Lév. [*M. alni*] on *Viburnum* (P); *Mycosphaerella effigurata* (Schw.) House on *Fraxinus americana* (B); *Nectria* [*Dialonectria*] *sanguinea* (Bolt. ex Fr.) Fr. [*N. episphaeria*] on *Diatrype stigma* (O, U); *Phyllachora graminis* (Pers. ex Fr.) Fuckel on *Elymus riparius, E. ? virginicus* (U); *Rosellinia clavariae* (Tul.) Wint. on *Clavaria* (K); *R. mammiformis* (Pers. ex Fr.) Ces. & de Not. on *Quercus* (U); *R. subiculata* (Schw. ex Fr.) Sacc. (K, S); *Sphaerotheca macularis* (Wallr. ex Fr.) W. B. Cooke [*S. humuli*] (U), on *Agrimonia striata* (B), on *Physocarpus* (I); *Stigmatea robertiana* Fr. on *Geranium robertianum* (P); *S. rubicola* (E. & E.) Theiss. on *Rubus pubescens* (= *R. triflorus*) (B); *Taphrina coerulescens* (Desm.) Tul. on *Quercus rubra* (C); *T. robinsoniana* Giesenh. (W); *Torrubiella arachnophila* (Johnst.) Mains var. *leiopus* Mains (stat. conid.: *Gibellula leiopus* (Vuill.) Mains) (E); *Tuber* sp. (G); *Uncinula flexulosa* Pk. on *Aesculus hippocastanum* (P); *Ustulina vulgaris* Tul. on *Fagus* (U); *Xylaria hypoxylon* (L. ex Fr.) Grev. (J); *X. mali* Fromme (U); *X. polymorpha* (Pers. ex Fr.) Grev. (I, R, U, W), on *Acer* (U), on *Quercus* (J).

DISCOMYCETES (sensu latu): *Agyrium* (?) sp. (C, T); *Aleuria aurantia* (Pers. ex Fr.) Fuckel (C, U); *Aleurina atrovinosa* (Cke.) Seaver (C); *Anthopeziza floccosa* (Schw.) Kanouse (C); *Bifusella linearis* (Pk.) Höhn. on *Pinus* (I); *Bulgaria* [*Phacobulgaria*] *inquinans* Pers. ex Fr. (C, K, O, R); *Chlorociboria aeruginosa* (Oeder ex Fr.) Seaver (C, J, O, U); *C. versiformis* (Pers. ex Fr.) Seaver (J, R, U); *C.* sp. (E); *Chlorospleniella* [*Coryne*] *sarcoides* (Jacq. ex Fr.) O. Kuntze (J); *Chlorosplenium chlora* (Schw. ex Fr.) Curt. in Sprague (C, U); *Cistella* sp. (U); *Corynetes atropurpureus* ([Batsch] ex Fr.) Durand (P); *C. robustus* Durand (C, D); *Cudonia confusa* Bres. (U); *C. lutea* (Pk.) Sacc. (C); *Dasyscypha diplocarpa* (Curr.) Boud. (C); *D. inquilina* (Karst.) Wint. on *Equisetum hyemale* (C, I); *D. virginea* (Batsch ex Fr.) Fuckel (C); *Dermea hamamelidis* (E. & E.) Groves on *Hamamelis virginiana* (O); *Galactinia brunneo-atra* (Desm.) Boud. (U); *G. limosa* (Grel.) Le Gal & Romagn. (C); *G. olivacea* (Boud.) Boud. (C); *G. praetervisa* (Bres.) Boud. (C); *G. succosa* (Berk.) Sacc. (C, J); *G.* sp. (C); *Geoglossum glabrum* Pers. ex Fr. (P, W); *G. nigritum* Cke. (K); *G. peckianum* Cke. (K); *G. simile* Pk. (K, U); *Helotium caudatum* (Karst.) Vel. (U); *H. citrinum* (Batsch ex Fr.) Fr. (C, L, R, U), on *Daedalea* (O); *H. cudonioides* Seaver (C); *H. fructigenum* (Bull. ex Fr.) Karst. on *Carya, Quercus* (C); *H.* spp. (C), on *Betula, Fagus, Quercus* (C); *Helvella elastica* Bull. ex Fr. (C, H, O); *H. lacunosa* Afzel. ex Fr. (U); *H.* [*Macropodia*] *macropus* (Pers. ex Fr.) Karst. (C, O); *Holwaya leptosperma* (Pk.) Durand [*H. gigantea, H. ophiobolus*] (I, Q, R, U), (stat. conid.) (B, U), on *Acer* (U), (stat. conid.) on *Fagus* (J), on *Tilia* (?) (I, O); *Humaria* [*Lachnea*] *scutellata* (L. ex Fr.) Fuckel (C, U), on *Acer* (U); H. [*L.*] spp. (C), on *Fagus* (C); *Hyaloscypha atomaria*

(Starb.) Nannf. on *Pinus strobus* (N); *H. dematiicola* (B. & Br.) Nannf. (O), (stat. conid.: *Haplographium delicatum* B. & Br.) (I); *Hypoderma brachysporum* (Rostr.) Tubeuf on *Pinus* (I); *H. rubi* (Pers. ex Fr.) de Not. on *Rubus* (U); *Karschia lignyota* (Fr.) Sacc. on *Betula* (U); *Leotia chlorocephala* Schw. ex Fr. (U); *L. lubrica* (Scop.) ex Fr. (I, O, Q); *L. viscosa* Fr. [*L. stipitata*] (L, N, O, W); *Leucoscypha* [*Lachnea*] *leucotricha* (A. & S. ex Fr.) Boud. (C, K); *Microglossum fumosum* (Pk.) Durand (P); *M. rufum* (Schw.) Underw. (L, N, P); *Mycolachnea* [*Lachnea*] *hemisphaerica* (Wigg. ex Fr.) Maire (C); *Ombrophila clavus* (A. & S. ex Fr.) Cke. (C); *Orbilia inflatula* Karst. (U); *O. xanthostigma* (Fr. ex Fr.) Fr. (C, S, U), on *Tsuga* (U); *Pachyella depressa* ([Phil.] Sacc.) Boud. (C); *Pezicula rubi* (Lib.) Niessl in Rabh. on *Rubus* (U); *Peziza clypeata* Schw. (C, J, U); *"P."* [*Paxina*] *fusicarpa* Gerard (C, N, O); *P. recedens* (Boud.) Sacc. & Syd. (C); *P. repanda* Karst. sensu Le Gal (C); *P. repanda* Fr. on *Acer* (U); *P. sylvestris* (Boud.) Sacc. & Trott. (C, H); *Propolis faginea* (Schrad.) ex Karst. (O); *Psilopezia ? aquatica* (DC. ex Fr.) Rehm in Sacc. & Sacc. (C); *Rhytisma acerinum* (Pers.) ex Fr. (I), on *Acer rubrum* (U, W); *R. andromedae* (Pers.) ex Fr. on *Andromeda glaucophylla* (B, C, I, L, N, U); *Rutstroemia macrospora* (Pk.) Kan. in Wehm. (C, O, U); *R.* sp. on *Acer* (C); *Saccobolus kerverni* (Crouan) Boud. (C, N); *Scodellina* [*Otidea*] *alutacea* (Pers. ex Fr.) S. F. Gray (A, C); *Tapesia* sp. (C); *Trichoglossum farlowii* (Cke.) Durand (N); *T. hirsutum* (Pers. ex Fr.) Boud. (C, L, P); *T. walteri* (Berk.) Durand (C, K, N); *Trichophaea* [*Lachnea*] *pseudogregaria* (Rick) Boud. (C); *Wynnea americana* Thaxter (C, P).

UREDINALES: *Coleosporium solidaginis* (Schw.) Thüm. on *Solidago* (A, N, W), on *S. flexicaulis, S. juncea, S. rugosa, Aster macrophyllus* (U); *Cronartium ribicola* Fisch. III on *Grossularia* (B); *Gymnoconia peckiana* (Howe) Trott. III on *Rubus pubescens* (= *R. triflorus*) (B); *Gymnosporangium globosum* Farlow I on *Crataegus* (B, U); *Puccinia caricis* (Schum.) Schröt. on *Carex gracillima* (U); *P. circaeae* Pers. II, III on *Circaea quadrisulcata* var. *canadensis* (= *C. lutetiana*) (B, U, W); *P. heucherae* (Schw.) Diet. III on *Saxifraga* (U); *P. malvacearum* Bert. on *Malva* (A, N); *P. rubigo-vera* (DC.) Wint. var. *agropyrina* (Erik.) Arth. on *Clematis* (N); *P. violae* (Schum.) DC. III (U); *Pucciniastrum agrimoniae* (Schw.) Tranz. II, III on *Agrimonia* (U), on *A. ? gryposepala* (W), on *A. parviflora* (U), II on *A. striata* (B); *Uredinopsis mirabilis* (Pk.) Magnus II, III on *Onoclea sensibilis* (B); *Uromyces caladii* (Schw.) Farlow III on *Arisaema triphyllum* (B).

TREMELLALES: *Arrhytidia involuta* (Schw.) Coker (L); *Calocera cornea* (Fr.) Loudon (I, S, U), on *Acer* (?) (A, N), on *Quercus* (M); *Dacrymyces ellisii* Coker on *Platanus occidentalis* (M); *D. minor* Pk. on *Pinus strobus* (N); *D. palmatus* (Schw.) Bres. (O, S); *D. stillatus* Fr. [*D. abietinus*] (U); *Dacryomitra stipitata* (Pk.) Burt. (S); *Eocronartium muscicola* (Fr.) Fitzp. on *Ciimacium* (N), on *C. americanum* (E); *Exidia glandulosa* Fr. (M, S); *E. nucleata* (Schw.) Burt (Q, S); *E. recisa* Fr. (S); *Helicobasidium holospirum* Bourd. (I, N), on *Aspidium marginale* (N), on *A. spinulosum* (H, N), on *A. spinulosum* var. *intermedium* (H, O); *Phleogena* [*Pilacre*] *faginea* (Fr.) Lk. (L, O, U, W), on *Carpinus caroliniana* (P); *Pseudohydnum gelatinosum* (Fr.) Karst. (N, O, R, S, V), on *Quercus* (J); *Sebacina ? epigaea* (B. & Br.) Rea (S); *S. eyrei* Wakef. (E, N); *S. incrustans* (Fr.) Tul. (Q, S, U), on *Polystichum acrostichoides* (N); *S. podlachica* Bres. (N, S); *Stypella minor* A. Möller (S); *Tremella reticulata* (Berk.)

Farlow (L, M, S); *T. subanomala* Coker (S); *Tremellodendron candidum* (Fr.) Atk. (U); *T. merismatoides* (Schw.) Burt (N); *Tulasnella bifrons* B. & G. (N); *T. pruinosa* B. & G. (N); *Xenolachne flagellifera* Rogers on *Hyaloscypha atomaria* (N).

AGARICACEAE (sensu latu): *Agaricus placomyces* Pk. (C); *A.* sp. (R); *Amanita frostiana* (Pk.) Sacc. (C, E); *A. rubescens* (Pers. ex Fr.) S. F. Gray (C); *Amanitopsis vaginata* (Bull. ex Fr.) Roze (N); *A. vaginata* var. *fulva* (Fr.) Sacc. (E); *Armillaria mellea* (Vahl. ex Fr.) Quél. (N, U, W); *Asterophora lycoperdoides* S. F. Gray [*Nyctalis asterophora*] (C); *Claudopus nidulans* (Fr.) Karst. (E); *Clitocybe aurantiaca* (Wulf. ex Fr.) Studer (N); *C. catina* (Fr.) Quél. (O); *C. clavipes* (Fr.) Quél. (R); *C. ectypoides* Pk. (O); *C. illudens* (Schw.) Sacc. (O); *Clitopilus abortivus* (B. & C.) Sacc. (E, N, W); *Collybia confluens* (Fr.) Quél. (U); *C. dryophila* (Fr.) Quél. (E); *C. lacunosa* Pk. (H, O); *C. radicata* (Fr.) Quél. (N, W); *C. velutipes* (Fr.) Quél. (C); *Cortinarius armillatus* (Fr.) Fr. (E, O, W); *C. cyanopus* Fr. (W); *C. distans* Pk. (E); *C. lilacinus* Pk. (E); *C. semisanguineus* (Fr.) Kauffm. (E); *Crepidotus applanatus* (Fr.) Quél. (O); *C. mollis* (Fr.) Quél. (E); *Entoloma* [*Rhodophyllus*] *salmoneum* (Pk.) Sacc. (C); *Galerina hypnorum* (Fr.) Kühner (C, O), on *Sphagnum* (E); *Hygrophorus borealis* Pk. (H, O); *H. discoideus* Fr. (O); *H. flavescens* (Kauffm.) Smith & Hessler (H, O); *H. marginatus* Pk. (O); *H. miniatus* (Fr.) Fr. (C, N, O, W); *H. miniatus* var. *sphagnophilus* Pk. (O); *H. pratensis* Fr. (O); *Inocybe fastigiata* (Schaeff. ex Fr.) Quél. (H, O); *I. hystrix* (Fr.) P. Karst. (O); *I. pallidipes* E. & E. (O); *Laccaria amethystina* (Bolt. ex Fr.) B. & Br. (C, H, O); *L. ochropurpurea* (Berk.) Pk. (H, O.); *Lactarius fuliginosus* (Fr.) Fr. (O); *L. griseus* Pk. (I); *L. indigo* (Schw.) Fr. (N, O); *L. insulsus* (Fr.) Fr. (H, O); *L. lignyotus* Fr. (C); *L. mucidus* Burl. (O); *L. piperatus* (Fr.) S. F. Gray (O); *L. torminosus* (Fr.) S. F. Gray (O); *L. turpis* (Weinm.) Fr. (H, N, O); *L. vellereus* (Fr.) Fr. (O); *Lentinus cochleatus* Fr. (E); *Lepiota acutaesquamosa* (Weinm.) Gill. (H, O); *Marasmius ? androsaceus* (Fr.) Fr. on *Pinus* (E); *M. cohaerens* (Fr.) Quél. (F, O); *M. rotula* (Fr.) Fr. (W), on *Fagus* (U); *M.* sp. (cfr. *M. straminipes* Pk.) on *Pinus* (U); *Mycena haematopus* (Fr.) Quél. (C); *M. leaiana* (Berk.) Sacc. (E); *M. radicatella* (Pk.) Sacc. (O); *Naematoloma capnoides* (Fr.) Karst. (E); *N. sublateritium* (Fr.) Karst. (I, O, R); *Panellus* [*Panus*] *stypticus* (Bull. ex Fr.) Karst. (E, N, O, U); *Panus strigosus* B. & C. (E); *Pholiota albocrenulata* (Pk.) Sacc. on *Acer* (O); *P. erebia* (Fr.) Quél. (O); *P. squarrosa* (Fr.) Quél. (W); *P. squarrosoides* (Pk.) Sacc. (E); *Pleurotus applicatus* (Fr.) Quél. (U); *P. ostreatus* (Fr.) Quél. (E); *Plicatura faginea* (Schrad. ex Fr.) Karst. [*Trogia crispa*] (E); *Pluteus leoninus* (Schaeff. ex Fr.) Quél. (C); *P. umbrosus* (Fr.) Quél. (E); *Psilocybe atrobrunnea* (Lasch) Gill. on *Sphagnum* (E); *Russula virescens* Fr. (R); *Schizophyllum commune* Fr. (N, R); *Tricholoma personatum* (Fr.) Quél. (W); *T. scjunctum* (Fr.) Quél. (H, O); *T. terreum* (Fr.) Quél. (O); *Xeromphalina* [*Omphalia*] *campanella* (Fr.) Kühn. & Maire (C).

BOLETACEAE: *Boletinus pictus* (Pk.) Pk. (R); *Gyrodon merulioides* (Schw.) Singer (R); *Leccinum scabrum* (Bull. ex Fr.) S. F. Gray (N, R); *Paxillus involutus* (Batsch ex Fr.) Fr. (N); *Pulveroboletus retipes* (B. & C.) Singer (R); *Strobilomyces confusus* Singer (R); *S. floccopus* (Vahl. ex Fr.) Karst. (R); *Suillus americanus* (Pk.) Snell (N, O, R); *S. elegans* (Schum. sensu Fr.) Snell (N, R); *S. punctipes* (Pk.) Singer (R); *Tylopilus* [*Boletus*] *felleus* (Bull. ex Fr.) Karst. (W).

GASTEROMYCETES: *Bovista pila* B. & C. (N, O, U, W); *B.* sp. (E, I); *Crucibulum levis* (DC.) Kambly [*C. vulgare*] (L, O, R, W); *Cyathus striatus* Willd. ex Pers. (C, O, U, W); *Geastrum triplex* Jungh. (C); *Lycoperdon fuscum* Bon. [*L. dryinum*] (B); *L. perlatum* Pers. [*L. gemmatum*] (L, O, U, W); *L. pyriforme* Pers. (N); *L.* sp. (J); *Mutinus caninus* (Pers.) Fr. [*M. ravenelii*] (E, N); *Scleroderma aurantium* Pers. (J, L, O, U, W); *S. bovista* Fr. sensu Hollos (O); *S. lycoperdoides* Schw. (O); *S.* sp. (I); *Sphaerobolus stellatus* Pers. (C).

OTHER HOMOBASIDIOMYCETES: *Aleurodiscus oakesii* (B. & C.) Cke. (O, U, W), on *Ostrya* (N); *A. pini* Jacks. on *Pinus strobus* (N); *A.* n. sp. on *Fraxinus* (N), on *Ostrya* (N); *Asterostroma muscicola* (B. & C.) Massee (N); *Bjerkandera* [*Polyporus*] *adusta* (Willd. ex Fr.) Karst. (E, N, W), on *Carpinus* (?), *Fagus* (U); *B.* [*P.*] *fumosa* (Pers. ex Fr.) Karst. (N); *Calodon scrobiculatus* (Fr.) Karst. (R); *C. zonatus* (Batsch ex Fr.) Karst. (O, R); *Cantharellus cibarius* Fr. (C); *C. lutescens* (Pers.) ex Fr. (O, W); *C. tubaeformis* (Bull.) ex Fr. (J, L, N); *Cerrena* [*Daedalea*] *unicolor* (Bull. ex Fr.) Murr. (E, L, N, U, W), on *Acer* (U), on *Betula* (E); *Clavariadelphus truncatus* (Quél.) Donk (E); *Clavicorona pyxidata* (Pers. ex Fr.) Doty (L, W); *Coniophora olivacea* ([Fr.] ex Pers.) Karst. (N, R); *Coriolus* [*Polyporus*] *hirsutus* (Wulf. ex Fr.) Quél. (E); *C. pargamenus* (Fr.) Pat. (O), on *Fagus* (E, U); *C. versicolor* (L. ex Fr.) Quél. (R), on *Populus grandidentata* (U), on *Quercus* (E); *Corticium bicolor* Pk. (N, S); *C. filicinum* Bourd. on *Osmunda cinnamomea* (A, N); *C. lembosporum* Bourd. (E, N); *C. porosum* B. & C. (N); *C. punctulatum* Cke. (N); *C. scutellare* B. & C. (O); *C. sphaerosporum* (Maire) H. & L. (N); *C. tulasnelloideum* H. & L. on *Pinus strobus* (N); *Craterellus cornucopioides* ([L.] ex Fr.) Pers. (C, E, N, O, P, S); *Cyphella fasciculata* (Schw.) B. & C. on *Alnus* (E, K); *Cytidia salicina* (Fr.) Burt on *Salix* (J); *Daedalea quercina* (L.) ex Fr. (C); *Daedaleopsis* [*Daedalea*] *confragosa* (Bolt. ex Fr.) Schröt. (L, N, O, S, W), on *Betula* (E, U), on *Fagus* (U); *Dentinum repandum* (L. ex Fr.) S. F. Gray (C, E, O, R, S); *Exobasidium vaccinii* Fuckel ex Wor. (U), on *Andromeda glaucophylla* (B, N, U); *Favolus alveolarius* (DC. ex Fr.) Quél. (R); *Fistulina hepatica* (Huds.) ex Fr. (I, N); *Fomes fomentarius* (L. ex Fr.) Kickx. (N, S), on *Betula alba* (U), on *B. lutea* (E); *Ganoderma applanatum* (Pers. ex Fr.) Pat. (E), on *Prunus* (U); *G. lucidum* (Leyss. ex Fr.) Karst. [*G. tsugae*] on *Tsuga canadensis* (E); *Gloeophyllum* [*Lenzites*] *sepiarium* ([Wulf.] ex Fr.) Karst. (E, I); *Grandinia farinacea* (Pers. ex Fr.) B. & G. (O); *Hericium caput-ursi* (Fr.) Banker (O); *H. coralloides* (Scop. ex Fr.) S. F. Gray (O, R); *H. erinaceus* (Bull. ex Fr.) Pers. (P); *H. laciniatum* (Leers) ex Banker (R, W); *Hirschioporus* [*Polyporus*] *abietinus* (Pers. ex Fr.) Donk on *Fagus grandifolia* (B); *Hydnochaete olivaceum* (Schw.) Banker [*Irpex cinnamomeus*] (E, O); *Hydnum brevipes* (Coker) Snell (R); *H. cristatum* Bres. in Atk. (R); *H. fennicum* (Karst.) Sacc. (R); *Hymenochaete cinnamomea* (Pers.) Bres. (U); *H. episphaeria* (Schw.) Massee on *Acer* (U); *H. fuliginosa* (Pers.) Lév. on *Acer* (U); *H. rubiginosa* (Schrad. ex Fr.) Lév. (N, U, W), on *Quercus* (E); *H.* sp. on *Pyrus malus* (E); *Inonotus* [*Polyporus*] *cuticularus* (Bull. ex Fr.) Karst. on *Fagus* (U); *I.* [*P.*] *nidulans* (Fr.) Karst. (E); *I.* [*Poria*] *obliquus* (Pers. ex Fr.) Pilát (sterile) on *Betula lutea* (N); *I.* [*Polyporus*] *radiatus* (Sow. et Fr.) Karst. (U); *Laetiporus* [*Polyporus*] *sulphureus* (Bull. ex Fr.) Bond. & Sing. (N); *Lentaria* [*Clavaria*] *mucida* (Pers. ex Fr.) Corner (C, S, U, W); *Lenzites betulina* ([L.] ex Fr.) Fr. (E); *Leptoporus* [*Polyporus*] *semipileatus* (Pk.) Pilát (O, U); *L.* [*P.*] *semi-*

supinus (B. & C.) Pilát (O), on *Betula* (U); *L.* [*P.*] *tephroleucus* (Pers. ex Fr.) Quél. (O); *Merulius molluscus* Fr. (N); *M. tremellosus* Schrad. ex Fr. (C, E, U), on *Quercus* (M); *Mycoacia himantia* (Schw.) Mill. & Boyle (N); *Odontia arguta* (Fr.) Quél. (O); *O. bicolor* (A. & S. ex Fr.) Bres. (S); *O. fimbriata* (Pers. ex Fr.) Fr. (O, S); *O. fusco-atra* (Fr.) Bres. (O); *Onnia* [*Coltricia, Polyporus*] *tomentosa* (Fr.) Karst. (N); *Oxydontia fragilissima* (B. & C.) Miller (E); *O. setosa* (Pers.) Miller on *Pyrus malus* (E); *Oxyporus populinus* (Schum. ex Fr.) Donk [*Fomes connatus*] (O), on *Acer* (E, P); *Pellicularia isabellina* (Fr. ex Pers.) Rogers (O); *P. ochroleuca* (Bres.) Rogers (N); *P. pruinata* (Bres.) Rogers (N), (stat. conid.) (O); *P. vaga* (B. & C.) Rogers (N), on *Pinus* (N), on *Tsuga* (U); *Peniophora affinis* Burt (O); *P. aspera* (Pers.) Sacc. [*Odontia setigera*] (O, S); *P. byssoides* (Pers. ex Fr.) Bres. on *Tsuga* (N); *P. cinerea* (Pers. ex Fr.) Cke. (O); *P. cymosa* Rogers & Jacks. on *Tsuga* (?) (N); *P. filamentosa* (B. & C.) Burt (N, O, R); *P. heterocystidia* Burt on *Acer* (N); *P.* [*Odontia*] *hydnoides* Cke. & Mass. (S), on *Acer* (N); *P. longispora* (Pat.) Höhn. (O); *P. mutata* (Pk.) H. & L. (O, U); *P. nuda* (Fr.) Bres. on *Betula* (U); *P. velutina* ([DC.] ex Pers.) Cke. (O); *P. viticola* (Schw.) H. & L. (H, N); *P.* sp. on *Fagus* (U); *Phellinus* [*Fuscoporia, Poria*] *ferruginosus* (Schrad. ex Fr.) B. & G. (N, O, U); *P.* [*Fomes*] *igniarius* (L. ex Fr.) Quél. (W), on *Betula* (B, E), on *Ulmus americana* (U); *P. isabellinus* (Fr.) B. & G. [*Trametes tenuis*] on *Prunus* (U); *P.* [*Poria*] *laevigatus* (Fr.) B. & G. on *Betula* (E); *Phellodon amicus* (Quél.) Banker (R); *Phlebiella* [*Poria*] *candidissima* (Schw.) W. B. Cooke (E, O); *P. vaga* (Fr.) Karst. (N), on *Betula* (U); *Physisporinus* [*Poria*] *spissus* (Schw. ex Fr.) Murr. (N), on *Pyrus malus* (E); *Piptoporus* [*Polyporus*] *betulinus* (Bull. ex Fr.) Karst. on *Betula* (E); *Polyporus elegans* Bull. ex Fr. (E); *P. peckianus* Cke. (P); *P. picipes* Fr. (E, O); *P.* [*Leptoporus*] *spumeus* Sow. ex Fr. var. *malicola* Lloyd (H, O), on *Pyrus malus* (E, U); *Poria mutans* (Pk.) Pk. (H, O); *P. reticulata* ([Pers.] ex Fr.) Cke. (E); *P. subacida* (Pk.) Sacc. (O); *P. versipora* (Pers.) Baxter (O, U); *Poronidulus* [*Polyporus*] *conchifer* (Schw.) Murr. on *Ulmus* (N, O, W), on *U. americana* (U); *Pycnoporus* [*Polyporus*] *cinnabarinus* (Jacq. ex Fr.) Karst. (O); *Radulum radula* (Fr.) Naanf. [*R. orbiculare*] (U); *Sarcodon murrillii* Banker (R); *Serpula americana* (Burt) W. B. Cooke (E); *S.* [*Merulius*] *lacrimans* (Wulf. ex Fr.) Karst. (W); *Sistotrema confluens* Pers. ex Fr. (E); *Solenia candida* Pers. ex Fr. (J, S), on *Betula* (E), on *Pinus strobus* (N); *S. fasciculata* Pers. ex Fr. on *Betula* (E, I); *S. ochracea* Hoffm. ex Pers. [*Cyphella mellea*] (E); *Steccherinum laeticolor* (B. & C.) Banker (B); *Stereum cinerascens* (Schw.) Massee (U); *S. complicatum* (Fr.) Fr. [*S. rameale* (Schw.) Burt *non* (Berk.) Massee] (N), on *Betula* (U), on *Carpinus* (M), on *Quercus* (E); *S. fasciatum* (Schw.) Fr. (E, M, U); *S. frustulatum* (Pers. ex Fr.) Fuckel (W); *S. purpureum* (Pers. ex Fr.) Fr. (U); *S. roseo-carneum* (Schw.) Fr. (C); *S. rufum* (Fr.) Fr. on *Populus grandidentata* (E); *S. sanguinolentum* (A. & S. ex Fr.) Fr. on *Tsuga* (N); *S. striatum* (Fr.) Fr. [*Thelephora sericea* Schw. *non* Pers.] (M, N, O, U), on *Carpinus* (E, N, U); *S.* sp. (B), on *Quercus* (E); *Stromatoscypha* [*Porothelium*] *fimbriata* (Pers. ex Fr.) Donk (O); *Thelephora caryophyllea* (Schaeff.) ex Fr. (E, O); *T. regularis* Schw. (A, N); *T. terrestris* Ehrh. ex Fr. (A, N); *T.* sp. (L); *Tomentella biennis* (Fr.) A. M. Rogers (S); *T. botryoides* (Schw.) B. & G. (N, S); *T. ferruginea* (Pers.) Pat. (N); *T. fusca* (Pers. ex Fr.) Schröt. (N); *T. fusco-ferruginosa* (Bres.) Litsch. (N, S); *T. mucidula* (Karst.) H. & L. (N); *T. olivascens* (B.

& C.) B. & G. (N, S); *T.* [*Hypochnus*] *pallidofulva* (Pk.) Litsch. (O); *T. pannosa* (B. & C.) B. & G. (S); *T. spongiosa* (Schw.) H. & L. (*non sensu* Burt) (H, N); *T. subferruginea* (Burt) Donk (U); *T. tristis* (Karst.) H. & L. (N, S); *T.* n. sp. (N); *Trametes heteromorpha* (Fr.) Bres. (E); *T. lactea* (Fr.) Pilát [*Polyporus tulipiferae*] (O, U, W); *Trechispora brinkmanni* (Bres.) Rogers & Jacks. on *Ganoderma applanatum* (N); *Tyromyces chioneus* (Fr.) Karst. [*Polyporus albellus*] (O, U), on *Betula* (U); *Vararia investiens* (Schw.) Karst. (N), on *Fagus* (U).

FUNGI IMPERFECTI: *Acrothecium obovatum* Cke. & Ell. (I, O); *Bactridium flavum* Kunze ex Fr. (I, O); *Beauveria bassiana* (Bals.) Vuill. (I); *Bispora pusilla* Sacc. (O); *Botrytis micheneri* B. & C. [*Costantinella athrix*] (O); *Brachysporium apicale* (B. & Br.) Sacc. (I, O), on *Fagus grandifolia* (O); *B. obovatum* (Berk.) Sacc. (O); *Cacumisporium* sp. (I); *Calcarisporium arbuscula* Preuss on *Laccaria laccata, Leotia lubrica* (I); *C.* sp. on *Leotia lubrica* (I); *Cephalosporium* sp. on *Xylaria polymorpha* (I); *Cephalothecium roseum* Corda on *Dibotryon morbosum* (I); *Cercospora* sp. on *Barbarea* (I); *Chalara* sp. on *Solidago* (I); *Cladosporium grumosum* Lk. sensu Schw. on *Pteridium latiusculum* (U); *C. herbarum* Lk. ex Fr. (I); *C. lignatile* Schw. (O); *Clasterosporium fasciculare* (Corda) Sacc. (O); *Colletotrichum liliacearum* (Schw.) Ferraris on *Smilacina trifolia* (B); *C.* sp. (I), on *Tilia americana* (B); *Costantinella tillettei* (Desm.) Mason & Hughes (O); *Dactylium dendroides* Fr. on *Polyporus* (I); *Darluca filum* (Biv.) Cast. on *Puccinia violae* III (U); *Dendryphion atrum* Corda (O); *Diplocladium minus* Bon. (S); *Diplococcium spicatum* Grove (O); *Diplosporium polypori* Dearn. & House on *Polyporus tulipiferae* (U); *Discosia artocreas* Fr. [*Cryptostictella bractearum*] on *Tilia americana* (B); *Epicoccum* sp. on *Equisetum hyemale* (I); *Haplaria grisea* Lk. ex Chev. on *Fagus* (I); *Helicoma morgani* Linder (O); *H. mülleri* Corda (O); *H. perelegans* Thaxter (O); *H. proliferens* Linder (O); *Helicoon ellipticum* (Pk.) Morgan (O); *Helicosporium aureum* (Corda) Lindau sensu Linder (O); *H. lumbricoides* Sacc. emend. Matr. on *Populus* (O); *Helminthosporium cyclops* Drechsler on *Danthonia spicata* (U); *H. folliculatum* Corda (O); *H. persistens* Cke. (O); *H. simplex* Kunze ex Fr. (O); *H.* sp. on *Salix serissima* (B); *Marssonina grossulariae* (Oud.) P. Magn. on *Ribes prostratum* (W); *Menispora oligosperma* Corda (O); *M.* sp. (I); *Monotospora sphaerocephala* B. & Br. (O); *Oidium conspersum* (Lk.) Linder (I, O); *O. curtisii* (Berk.) Linder (I); *O.* sp. sensu Linder (C); *Papulaspora candida* Sacc. on *Trichoglossum hirsutum* (I); *Periconia byssoides* Pers. ex Corda (I); *Phragmocephala setosa* (B. & C.) Mason & Hughes (O); *Phyllosticta fraxinicola* Curr. on *Fraxinus lanceolata* (U); *P. minima* (B. & C.) Underw. & Earle on *Acer rubrum* (B); *P. tiliae* Sacc. & Speg. on *Tilia americana* (B); *Phymatotrichum* sp. (U); *Ramularia brunnea* Pk. on *Tussilago farfara* (U); *R. tulasnei* Sacc. on *Fragaria virginiana* (U); *Rhizoctonia* sp. on *Circaea lutatiana* (U); *Septonema pallidum* (Grove) Hughes on *Diatrype stigma* (O); *Septoria brunellae* Ell. & Holw. on *Monarda clinopodia* (U); *S. cornicola* Desm. on *Cornus racemosa* (B); *S. solidaginicola* Pk. on *Solidago latifolia* (U); *Sphaceloma plantaginis* Jenk. & Bit. on *Plantago rugelii* (U); *Sphaerographium fraxini* (Pk.) Sacc. on *Fraxinus* (I); *Sphaeronema* sp. on *Glonium stellatum* (U); *Sporidesmium concinnum* Berk. (I, O, U); *S. larvatum* Cke. & Ell. (O); *S. nitens* Schw. (O); *S. peziza* Cke. & Ell. on *Acer* (?) (U); *Sporoschisma insigne* Sacc., Rouss. & Bomm. on *Poria* (O); *S. mirabile* Berk. (O); *Sporotrichum agaricinum* Lk. on *Lactarius griseus*

(I); *Stephanoma strigosa* Wallr. (O), on *Mycolachnea hemisphaerica* (C); *Tilachlidium tomentosum* (Schrad. ex Fr.) Lindau var. *ovalisporum* A. L. Smith (O); *Torula uniformis* Pk. (O); *Trichoderma viride* Pers. ex Fr. on *Betula lutea* (I); *Tubercularia vulgaris* Pers. ex Hook. (I), on *Fagus, Ulmus* (U), on *Quercus* (N); *T.* sp. on *Quercus ? rubra* (B); *Verticillium tenuissimum* Corda (O).

LICHENS (all collections reported by Emanuel D. Rudolph): *Bilimbia* [*Bacidia*] *melaena* (Nyl.) Arn.; *B. naegelii* (Hepp) Kremphl.; *B. parasema* (Ach.) de Not.; *Cetraria oakesiana* Tuck.; *Cladonia fimbriata* (L.) Fr. var. *radicata* (Schreb.) Fr.; *C. foliacea* (Huds.) Schaer.; *C. furcata* (Huds.) Vainio var. *pinnata* (Floerke) Vainio; *Graphis scripta* (L.) Ach.; *Lecidea albocaerulescens* (Wulf.) Ach.; *L. cyrtidia* Tuck.; *L. platycarpa* Ach.; *L. viridescens* (Schrad.) Ach.; *Parmelia borreri* Turn.; *P. caperata* (L.) Ach.; *P. conspersa* (Ehrh.) Ach.; *P. olivacea* (L.) Ach.; *P. physodes* (L.) Ach.; *P. quercina* (Willd.) Vainio; *P. saxatilis* (L.) Ach.; *Peltigera canina* (L.) Willd.; *Pertusaria multipuncta* (Turn.) Nyl.; *Physcia endochrysea* (Hampe.) Nyl.; *P. stellaris* (L.) Nyl.; *P. tribacia* (Ach.) Nyl.; *Polyblastiopsis lactea* (Massal.) Zahlbr.; *Rinodina milliaria* Tuck.; *R. sophodes* (Ach.) Massal.—A. J. MIX.

UNIVERSITY OF KANSAS,
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REVIEWS

FLORE ANALYTIQUE DES CHAMPIGNONS SUPÉRIEURS (AGARICS, BOLETS, CHANTERELLES) COMPRENANT LES ESPÈCES DE L'EUROPE OCCIDENTALE ET CENTRALE AINSI LA PLUPART DE CELLES DE L'ALGERIE ET DU MAROC, by Robert Kühner and Henri Romagnesi. xiv + 557 pp., 677 figs. Masson & Cie., Paris 6e. 1953. Price, paper 7,010 fcs. ($20); bound 7,970 fcs. ($22.75).

This is a descriptive key to the better known higher fungi of western Europe and North Africa, but with particular emphasis on the flora of France. It includes both the boletes and gill fungi.

To place this work in its proper perspective, it should be kept in mind that the past twenty years of taxonomic research have been characterized by a search for new and more accurate characters by which to recognize taxa among the higher fungi, and an attempt to re-evaluate all characters in seeking the establishment of a natural classification. The authors of the work under consideration have been prominent in this two-fold approach, and for this reason the present summary of their efforts commands the respect and attention of all who study fleshy fungi.

There are so many aspects of the work worth discussion in such a review as this, that it seems best to take them up individually.

Physical features: In this respect the book will stand comparison with any. It is on good paper, is well bound, and of medium size (19½ × 27 cm.). The printed page is 14 × 20.5 cm. The originals of the illustrations are ink drawings. The illustrations occupy the top part of the page unless there are enough for a full page, as for instance on p. 213. The work is a series of descriptive keys which take one eventually to species. A great effort has been made to save space, and one method was to use 8 pt. type throughout the keys and observations. However, it is easy to read, something one might not expect because of the small size. Bold face type has been used for all recognized species names, and important characters are also often given added emphasis by being set in boldface. An excellent (in fact the best yet done) comparison in key form of the Friesian system of genera and subgenera with a modern classification is given, following brief introductory and explanatory remarks. There is a brief but very valuable chapter on techniques and a good glossary. A chapter of additional comments follows a 2 page chap-

ter giving a comparison of the color terms used by Saccardo with the color charts of Klinksieck and Valette and also of De Seguy. Then follows the index to illustrations, genera and species. The book shows the results of much careful planning for ease in use, and users of it will always be grateful for this effort on the part of the authors. This consideration for the reader is in decided contrast to that shown in an important recent English work which appeared with no page index to species names.

Authors' aims: It is not fair to criticize a work without taking the objectives of the authors into account, so a brief statement of them is made here in order to give the reader of this review the proper background. The authors keenly realized the faults of much of the European literature on higher fungi—particularly the habit of "borrowing" from Fries instead of giving original observations. Kühner and Romagnesi have made a great effort to see to it that their work is based on original observations. This of course pleases this reviewer no end because he has always stressed original observations in his own work. As the authors admit, this approach prevents them from taking all the described species into account and thus the work is not "complete." To experienced mycologists who understand the situation, this is no drawback—they all realize that no truly complete flora of mushrooms has ever been written for any region and will not be for many years to come. The authors, in their key, have tried to place emphasis on natural relationships as seen in the light of *all* the characters of a species—macroscopic, microscopic, and chemical. I give this viewpoint hearty support also. Within this structure they have tried to establish generic concepts which would involve as little name changing as possible. After reading their introduction your reviewer felt like the man who went to church and heard the preacher deliver a sermon. Because the sermon agreed entirely with the man's beliefs, he was very pleased with it. Aside from this personal slant, however, I believe all investigators will eventually find that the "original" approach is the only one which will give valuable, long-range results.

Generic concepts: I am sure it was a distinct surprise to all of us who had closely followed the work of these investigators during the past twenty years suddenly to find them switching over from narrow generic concepts to those as broad as or broader than established by Quélet in his later works. Those who follow their classification can now call a bolete *Boletus* again, though it will surprise nearly everyone to see *Strobilomyces* and *Boletinus* reduced to synonomy with *Boletus*. *Pax-*

illus and *Gomphidius* are recognized as genera of gill fungi more closely related to *Boletus* than to the true gill fungi.

I am particularly pleased to see prominent European authors recognizing *Hygrophorus* as a genus with *Hygrocybe, Camarophyllus* and *Limacium* as subgenera. I shall not venture to criticize their treatment of the pleurotoid fungi (*Pleurotus* sensu lato—with some additions) because of my own hesitation over generic concepts in this group. The concept of *Mycena* is more restricted than in either Kühner's or my own monograph, with additions going to *Delicatula* and *Omphalia*. However, even though as a rule I favor large genera, I do not believe that their concept of *Omphalia* will stand—it contains, to my mind, some quite unrelated species. The concept of *Hygrophoropsis* is good, as is that of *Lyophyllum,* although the latter is still a difficult genus to define on a natural basis. There is not space in this review for comments on all genera. As one would expect, individual investigators will take issue with the authors on many points, such as including *Phaeolepiota aurea* in *Cystoderma,* but the diverse treatments of genera by different authors focus attention on the fact that at the present time the world over we are all trying to re-evaluate characters in the higher Basidiomycetes and our opinions are bound to differ greatly in many areas of the field. Although I would reserve the right to disagree with the authors on many points I truly regard their going back to broad generic concepts as a healthy move calculated to throw the numerous small genera described in recent years into a more critical focus.

Nomenclature: For those who at least try to follow the International Code, the nomenclature is the most disappointing aspect of the work. The authors have elected to follow their own Code, briefly stated in the introduction, and this will lead to a number of their names not being accepted by other workers. Authorities for species are not given according to the International Code and the procedures for describing new species are not followed. I consider this a major defect, and one which could have been avoided without too much additional work. The best any of us can do is to make an honest attempt to follow the International Rules, and this they could easily have done even though some problems might have remained unsolved. Flagrant violations of the rules on priority occur, such as the recognition of *Cortinarius mucifluoides* Henry (1950) and the placing of *C. pseudosolar* Lange (1938) as a synonym under it.

Adequacy of the descriptive material: We must consider this subject in relation to the type of presentation—a descriptive key. A descriptive key is a poor vehicle at best, but it can be honestly stated that the authors

have done well within the limitations of their vehicle. Theirs is the best and most comprehensive descriptive key for higher fungi yet published. We used this book last summer in the group of advanced students and investigators studying fleshy fungi at the University of Michigan Biological Station. Many species, previously difficult of identification, key out very smoothly in this work. Our trouble came when species were encountered which were not treated in the book, or when we took up such difficult genera as *Russula, Cortinarius* and *Inocybe*. Our consensus of opinion was that the treatment was not sufficiently detailed to enable one to make accurate comparisons between the flora of France and Michigan. This was especially true in trying to arrive at concepts of some of the new species they described. Since both authors are masters of the art of accurate description, as evidenced in the bulk of their previous work, we all hope they will treat the species published as new in this book in greater detail elsewhere at a later date and add the validating Latin descriptions which are now lacking.

Species concepts: In using the term "species concept" here, it is restricted to apply to situations in which it is found that more than one species is being designated, in the literature, by a single binomial. In the other, and perhaps more common use of the term, i.e. whether author A has a broad or narrow concept of a species, it can be said that the authors of this book have tried to maintain broad rather than narrow species concepts. The type of concept discussed here could just as well be termed misidentifications by prominent investigators if it were not for the fact that in most such instances there is no authentic material to go back to to determine who is "right." Consequently, different species still continue to be designated by the same binomial. The present work does not offer much help in solving such questions, nor was it designed to do so. An example of this type of situation is as follows: *Tricholoma elytroides* Fries is listed among the species of *Tricholoma* having amyloid spores. At an earlier date Ricken, and later Nüesch, in his monograph, described a different species under the same name. Most of us have accepted the concept of *T. elytroides* of Ricken and Nüesch as satisfactory. Kühner and Romagnesi propose a *new* concept under this same name, one which, as far as *macroscopic characters* go (the ones Fries used), does not fit Fries's description and illustration any better than that of Nüesch (there are some discrepancies in both descriptions). It seems to me that, though this sort of thing has been common in the past, it is now time to stop adding *new* concepts to Friesian species unless one has had access to clearly authentic material—which is not the case here.

Thus, one must check rather carefully in the present work to see just what particular fungus is passing under a given binomial.

The characters used and their evaluation: In this regard the over-all aspect of the book is favorable, but we found the *Russula* key very difficult to use because, possibly, we were using it for a lot of species not included. For some species this was clearly evident, but for others the issue remained doubtful. The *Cortinarius* key is also unsatisfactory to a foreign investigator like myself. In the first place, redefining *Myxacium* to include species lacking a viscid stipe is, in my estimation, poor judgment. I appreciate the desirability of a natural classification as much as any one, but also believe that relationships within a genus can be recognized without confusing the definition of the subgenera and sections. If the genus really is "natural" it stands to reason that within the subgenera one can expect to find a situation in which two species, each from a different subgenus, are more closely related to each other than each is to individual species in the main body of its respective subgenus. If this were not true there would be a strong argument in favor of raising the subgenera to generic rank. Continuing with the subgenus *Myxacium* of *Cortinarius*, it appears to me that many of the key characters are actually trivial, i.e. in the Colliniti, growing above the tree line in mountains for *C. alpinus* is the first choice. The next choice, based on cap color, is equally undesirable. The presence or absence of clamp connections on the cuticular hyphae and the color of the young gills are far more reliable in the material I have seen. The use of the presence or absence of cheilocystidia is good. The use of size I deplore; on the basis of my own experience, it is extremely unreliable and should be used very cautiously. One trouble the authors faced was that of trying to arrive at a natural classification with only a meager flora at their disposal. They include only 21 species in *Myxacium* (counting 4 which I would exclude) as contrasted to 46 known for North America. Realizing this handicap, in my opinion they would have done better in this genus to adhere more closely in the main characters of the key to those which clearly indicate relationship. In such genera as *Coprinus* and *Drosophila* (*Psathyrella*) the authors have done much better in this respect.

In summary, it can be said that the authors have made a major contribution to our knowledge of the higher fungi. No investigator in this field can afford to disregard it. Because of its importance, I have felt it my duty to dwell, perhaps a little too long, on its shortcomings in order that these may be evident, particularly to "foreigners" like myself who will be using it every day in the comparison of their floras with that of France. No one appreciates the difficulties involved in the production

of such a work as this more than I do. We are all grateful for their effort.—ALEXANDER H. SMITH.

The book by two outstanding French mycologists who have in the past contributed—and are still contributing—so much to the position their country occupies as the foremost center of European agaricology, has been expected impatiently in France and all over the world. To those who have dedicated their efforts to the exploration of the taxonomy of Agaricales in extraeuropean regions, the knowledge of the species occurring in Europe is vital. For the Europeans, the last few years have added three important books on determination of Agaricales, Pilat's "Klič," Moser's "Kryptogamenflora," and now Kühner and Romagnesi. The book, pleasantly presented in binding and on good paper, in clear print with very few printing errors, has, as the authors say, predominantly practical significance—i.e., to give students of the group an easy dichotomous key to arrive at the species in a modern concept, a feat thus far possible only after long and often disappointing literature studies. Every one of the recent publications has its advantages: Pilat's book is perhaps the most complete as to the species described and photographed but lacks some anatomical detail and is written in a language not easily understood by most botanists; Moser's book, most handy in format, is, in the reviewer's opinion, most logical in its classification and presentation of the specific diagnoses and also tries seriously to comply with the nomenclature rules, although wanting in microscopical detail in genera like *Pluteus* and *Russula,* which cannot be determined in a field book. Kühner and Romagnesi is most judicial and economical in the use of diagnostic characters and obviously the most personal of these books, meticulously avoiding literature data, and for the most part confining itself to data obtained by the studies of the authors themselves (with some other specialists such as Henry and Favre collaborating on certain groups). The classification and the keys themselves are, where they were not done by one author alone, the result of a compromise, and frequently sacrifices were made to natural classification by practical considerations (as explained in the preface, with special reference to *Rhodophyllus* and *Russula*). The reviewer has given the family keys a superficial test. While they are sound for the most part, he was unable to key out *Cystoderma* in the Lepiotaceae. The authors have divided the "higher fungi" into thirteen families. This classification comes rather close to that of the reviewer published in 1951 (which, however, was not taken into consideration by the authors because by that time

their manuscript had progressed too much to be changed in any detail, according to personal communication by H. Romagnesi); indeed some families coincide in both classifications. It may be questioned why the authors have included the Orcelles in the Tricholomacées, why they have included part of the Tubariaceae in the Tricholomées and another part in the Naucoriacées, why they have seen fit to separate *Panaeolus* so far from the Coprinaceae; but since Romagnesi, in an extended review of Singer, The Agaricales, has already attempted to justify some of these solutions by criticizing the reviewer's differing point of view, and, mainly, because it is the reviewer's conviction that in a book review, unless purposely polemical, no fully satisfactory assemblage of reasons for or against certain taxonomical arrangements can be given, it is here merely indicated that some, mostly minor, points of discord remain to be judged by the users of both classifications. It seems, however, that a glimpse at the world flora of Agaricales, beyond the limits of west European experience, would have made it possible to solve at least some of the questions left in an unsatisfactory state, while others should not have become so difficult to solve if the authors had not taken a definitive stand against the modern tendency of adapting agaric and bolete genera to the size now generally considered acceptable in systematic botany, which is, at the same time, a stand against their own taxonomic past (1926–1950). Perhaps a majority of the European readers will thank the authors for their attempt to maintain intact some of the older genera such as *Boletus* or *Panaeolus,* but whether it will be practically useful for the amateur and beginner to see *Naucoria* in a wide sense conserved, and then find half the species entering *Naucoria* in the classical and semiclassical works thrown out and dispersed among other genera, is disputable. Again, it seems useless, in a review, to dwell on the minority of cases where the reviewer's opinion differs from that expressed in the book under consideration. However, in most cases of this kind, the authors prudently point out that the assemblage of species or groups is more or less artificial.

Numerous schematized line drawings throughout the text have been adapted by Romagnesi, mainly from illustrations by other authors. These drawings should prove a most valuable help to those using the keys, especially beginners. It is likewise mainly the latter who will profit by carefully studying the technical advice and glossary given in the concluding chapters of the work, pp. 487–508.

The description of the species in key-form has something of the elegance of the Linnean "diagnosis" in its original sense, but for new and little known species the absence of a routine description is deplorable.

The best pictures are cited and, in separate notes, on species presumably related but not known to the authors personally, valuable supplementary indications are given. Since the correct determination of species within the range of the Flora by a public not necessarily restricted to specialists but including the more ambitious amateurs, is evidently the aim of the publication under review, it must be stated that this aim has generally been reached, and the authors should be congratulated for the successful termination of an effort of many laborious years.

A serious shortcoming, however, is the complete neglect of the nomenclatorial rules. This neglect is intentional, and the authors have gone so far as to point out their own rules of nomenclature as at variance with those accepted at the international congresses. There is no rule in the code that has not been violated in the book here reviewed. It is not merely a question of adherence to some internationally acknowledged code of naming organisms: it is the very vital question of continuity in mycological nomenclature that is at stake. The authors claim that the rules were made "by and for phanerogamists." This statement is not valid. It is further stated that such names as *Dryophila* Quél. that are relatively closest to the conception of a generic group as used by the authors, are more in keeping with justice (apparently in regard to Quélet) than the legal name (*Pholiota*). Nomenclature is not concerned with giving premiums for fortunate taxonomic groupings but with the uniformity and continuity of botanical names. It cannot be assumed that in 1953 generic names like *Dryophila* (instead of *Pholiota*) or *Geophila* (instead of *Stropharia*), should have any appeal at all among other mycologists. The starting point of Agaricales nomenclature with Fries's Systema Mycologicum is a solution of debatable virtue. But the vast majority of mycologists feel that it is far too late to change the starting point, especially if this is done in an individual work outside the international congresses in order to suit one's own preferences. Taking furthermore into consideration all the other, minor and not deliberate deviations from the rules as practiced by the authors, even against their own rules (e.g. *Boletus cramesinus* vs. *B. sanguineus!*), one feels some hesitation in giving a purely formal problem too much room in a review. May it suffice to point out that the author quotations are more often inaccurate than not. The "Kühner & Romagn." is found entirely too often after "new" combinations (*Lyophyllum* spp. p. 166, *Agrocybe firma*, etc.) or is omitted where it would have been legitimate. Subgenera and varieties often replace genera or species over which they have priority, and the same specific epithet with a single type shows up in two different genera (see *Clitopilus* and *Hebeloma truncatum*). We even

find old specific epithets subordinated as varieties to more recent specific names (*Russula firmula* J. Schaeffer var. *cinnamomicolor* Krombh., p. 464). If these were occasional errors, they might pass, but the reviewer cannot help feeling that the authors have quite generally shown a deplorable lack of consistency and precision in this regard.—R. SINGER.

THE GENERA OF THE HOMOBASIDIOMYCETES (EXCLUSIVE OF THE GASTEROMYCETES), by Wm. Bridge Cooke. Special Publication No. 3, Div. Mycology and Disease Survey, Bur. Pl. Ind., Soils and Agr. Eng., U. S. Dept. Agriculture. 100 pp. (offset). 1953.

An alphabetical list of all generic names which have been used within the limits indicated, with author, place of publication, family to which commonly assigned and type species or, in cases where author did not indicate type species, lectotype, with assignment of authors responsible for suggesting it. In some instances, the author of the present list has selected a lectotype. The list is thought to be complete to September 1, 1952. There is a bibliography of 38 titles.

AN ANNOTATED BIBLIOGRAPHY OF COFFEE RUST (HEMILEIA SPP.), by John A. Stevenson and Rose Beam. Special Publication No. 4, Div. Mycology and Disease Survey, Bur. Pl. Ind., Soils and Agr. Eng., U. S. Dept. Agriculture. 80 pp. (offset). 1953.

Nearly 1000 titles are listed, 11 of which refer to *H coffeicola*, the rest to *H. vastatrix*, its effects on the host or proposed remedial measures. Of particular interest to plant pathologists. Many of the articles cited are in the nature of local reports of limited circulation, the existence of which would be largely unknown to most workers unless a list of this sort were to cite them.

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